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FIELD GUIDE

GEOLOGY OF COALINGA, CENTRAL SAN ANDREAS FAULT AND THE PINNACLES NATIONAL MONUMENT

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FIELD GUIDE

COALINGA TO THE PINNACLES
ALONG THE SAN ANDREAS FAULT ZONE

Sponsored by

UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF LAND MANAGEMENT

BAKERSFIELD DISTRICT OFFICE

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OVERVIEW

This trip begins at the R. C. Baker Memorial Oil Museum located at 297 Elm Street, Coalinga, Ca., and continues along State Highway 198 with stops at the Coalinga Sulphur Baths & Plunge (just outside of Coalinga) and Coalinga Mineral Hot Springs County Park (farther along State Highway 198). Proceed west on State Highway 198 to the intersection of State Highway 25. Turn north at this intersection. The road parallels the San Andreas Fault Zone for the rest of the trip. The lunch stop is in Bitterwater Valley at a private home located 0.4 of a mile before the Bitterwater School. The trip will continue along State Highway 25 and end at the Pinnacles National Monument.

FIELD STOPS

FIGURES

TABLES

MAPS

ROAD LOG

0.0 STOP # 1. R. C. BAKER MEMORIAL OIL MUSEUM

The R. C. Baker Memorial Oil Museum is located at 297 Elm Street, Coalinga, Ca., phone number 1-209-935-1914. The museum will be open from 9:00 a.m. to 9:30 a.m. prior to the field trip especially for our convenience. Our host is William Delco. The museum normally opens on Saturday at 11:00 a.m. Entrance to the museum is free, but donations to support the organization are welcome. This museum is named after a prominent oil pioneer, Ruben Carlton Baker, founder of Baker Tools.

Coalinga

The town of Coalinga, incorporated in 1906, acquired its name from the Southern Pacific Railroad. The name "Coalinga" is a contraction of Coaling Station A, a siding to load up coal onto the rail lines in the 1880's. Coalinga is located at the western edge of the San Joaquin Valley approximately 60 miles southwest of the city of Fresno.

The area, as is common on the west side of the valley, has bad water. Most establishments had three faucets, one for the drinking water that was shipped in by rail, and other two for other usage that was from well water pumped from the ground. For several years, Coalinga had a desalinization plant to purify its water. Currently all water comes from the California Aqueduct.

Earthquake of May 2, 1983

On May 2, 1983, 7.5 miles (12 kilometers) northeast of Coalinga in the East Coalinga Extension Oil Field (east of State Highway 33) on the Coalinga Anticline was the epicenter of a 6.7 magnitude earthquake causing over $31 million dollars of damage. The main shock was 16 miles (25.6 kilometers) beneath the surface on a buried thrust/reverse fault. This event was not associated with any previously known or suspected active fault. The shock was felt in the south from Los Angeles to 320 miles (512 kilometers) north of Sacramento and as far east as Las Vegas. Major surface damage and minor subsurface damage occurred in the oil fields in the epicenter vicinity.

The San Joaquin Valley is a broad asymmetric trough paralleling the San Andreas Rift Zone. Its sedimentary sequence ranges in age from the Late Jurassic through Holocene and is chiefly marine origin upward into the Pliocene sequence. The fill conceals the eastern margin of Franciscan rocks, which underlie the Diablo Range (directly west of Coalinga), and the western margin of the Sierran basement.

GEOLOGICAL TIME SCALE
(In use by the
U. S. Geological Survey)

Era or Erathem	System or Period	Series (Epoch)	Age Estimates (boundary in millions of years ago)
		Holocene	
	Quaternary	Pleistocene	
			1.8
		Pliocene	
			5.0
		Miocene	
			22.5
Cenozoic		Oligocene	
			37.5
		Eocene	
			53.5
	Tertiary	Paleocene	
			65.0
	Cretaceous		
			136.0
Mesozoic	Jurassic		
			190-195.0
	Triassic		
			225.0
	Permian		
			280.0
	Pennsylvanian		
			320.0
	Mississippian		
			345.0
Paleozoic	Devonian		
			395.0
	Silurian		
			430-440.0
	Ordovician		
			500.0
	Cambrian		
			570.0
Precambrian			

TABLE # 1. Geological Time Chart. U. S. Geological Survey.

A 32 to 48 mile wide band of narrow elongate folds, many containing oil fields, extend along the west side of the valley. Fold axes generally trend subparallel to the San Andreas Fault, and many are cut by hidden or known reverse faults of similar trend as the Coalinga situation. In the Coalinga area, within the sedimentary rocks an anticlinal fold (the Coalinga-Kettleman Hills-Lost Hills anticlinal trend) has developed subparallel to the San Andreas fault.

Studies suggest a buried wedge of Mesozoic oceanic crust is being forced from the Diablo Range eastward beneath a thick section of Cretaceous and younger sedimentary rocks. Ascending from the San Joaquin Valley east to west a cross section of the Diablo Range reveals the valley floor sequence in outcrops. A typical sequence of outcrops encountered is first, the younger Pliocene Etchegoin to older Cretaceous Panoche Formations, second, a thrust fault, and third the sequence is repeated again with the younger Pliocene Etchegoin to older Cretaceous Panoche Formations. In turn this sequence is thrust over the Franciscan Melange.

The western and eastern margins of the central Coast Ranges and the Transverse Ranges are characterized by isolated clusters of thrust/reverse faults, on which earthquakes occur. Examples of similar greater than 5.0 magnitude earthquakes are the 1971 San Fernando, 1973 Point Magu, 1978 Santa Barbara, and the 1980 Point Sal.

Analysis of alluvial deposits laid down by a steam cut through the Coalinga anticline indicates that major earthquakes with the same amount of uplift as in 1983 have a minimum average repeat rate is in the range of 200-1000 years during the past 2000 years.

Mining Activities

The townsite of Coalinga rests on Quaternary sands and gravels in Pleasant Valley. Mining, mineral, and geological interest in the Coalinga area began in the surrounding hills with the discovery of mercury in 1853 and the mining of a low grade of coal (lignite) for a short time beginning in 1877. Later on, asbestos, limestone, and mineral water were also mined or produced in the Coalinga vicinity.

Mercury

The mercury and asbestos deposits are found in both Fresno County and San Benito County about 18-20 miles northwest of Coalinga in the New Idria Mining District.

The major structure of the district is a pluglike mass of older serpentine and Franciscan graywacke thrust up through the shale and sandstone of the younger Cretaceous Panoche Formation and Tertiary

sedimentary rocks. The mass of serpentine and Franciscan graywacke is in size, 13 miles (22 kilometers) long and 4½ miles (7 kilometers) wide. Along the margins and within the mass are numerous steeply dipping thrust faults.

Mercury occurs chiefly in altered and indurated Cretaceous Panoche rocks beneath the New Idria thrust fault, and irregularities in the plane of the fault have closely controlled zones of deposition. Cinnabar (principle ore of mercury) fills the open spaces, forming veins and stockworks, with rich ore formed when the fracturing was most intensive. Known ore deposits extend in places through a vertical range of more than 1,400 feet and a horizontal span of about ten miles. The same ore deposit is the source of the state gem of California, the unique pale blue benitoite, a barium titano-silicate.

In Fresno County one of several mercury mines was the Archer mercury mine, founded in 1904. The mine workings are in the Cretaceous Panoche Formation at a fault contact along the southeast end of a body of serpentine which extends from San Benito County into western Fresno County. The adit workings are perpendicular to the fault line which strikes northeastward crossing six shear zones. The ore contained up to 1½% mercury.

In southern San Benito County, in the New Idria Mercury Mining District, the New Idria mine ranked first in production of mercury in North America in 1965. Production has been more than 500,000 (76½ lb.) flasks.

per flask.

Asbestos

Within the New Idria Mining District's the large serpentine mass contains one of the largest asbestos deposits in the world. The mass has been highly sheared and recrystallized to flaky, matted chrysotile asbestos. Highly prized because of whiteness and the ability to absorb hydrocarbons, the deposit of over 100 million tons of ore was first developed in 1959 by the Union Carbide Nuclear Co. The Coalinga Asbestos Company and the Atlas Corporation were involved in the further development of the deposit.

In Fresno County a long-fiber (up to three quarters of an inch) asbestos deposit was prospected on the Ross-Garcia asbestos claims located in Sec. 21, T. 19 S., R. 13 E. about 15 miles northwest of Coalinga. No production was recorded.

Production of mercury and asbestos has almost ceased because of the increased awareness of the association of mercury to cancer and asbestos to lung diseases. The land is being managed by the Bureau of Land Management through the Hollister Resource Area Office.

Coal

Coal has been known for many years both northwest and southwest of Coalinga along the eastern slopes of Diablo Range. Coal is formed in tropical conditions. Its presence suggests a swampy, highly vegetated, and warm climate during the formation of the coal beds in the Eocene.

About four miles west of Coalinga was the California Coal Mine, located in Sec. 22, T. 20 S., R. 14 E. at an elevation of about 1300 feet. This mine was first worked through a series of adits and later by a 400-foot incline. It was the only coal mine on which any work was done since 1896. In July, 1940 a small amount of lignite was mined.

Three miles west of Coalinga was the San Joaquin Valley Company's Coal Mine on the west side of Sec. 26, T. 20 S., R. 14 E., at an elevation of about 1100 feet. This was the most extensively worked of the Fresno County coal mines. It had adits 300, 400, and 1700 feet long and an incline 300 feet long. It contained several small seams of low grade lignite three to seven inches thick and a seam 4½ feet thick.

The coal ventures failed by the early 1890's because of limited coal mine capacity and the poor quality of the coal itself. It was said the burning a pound of Coalinga coal produced two pounds of ashes.

Fossils

The area around Coalinga is well known for its fossils. The most common fossils, (other than microfossils), are the Delectopecten, Macrocalista, Nuculana, and Thyasira (all pelecypods). These fossils are found in scattered locations north of Coalinga particularly in Sec. 36, T. 16 S., R. 13 E. Another extremely fossiliferous area north of Coalinga is the Turritella ocoyana bed northeast of the Universal Oil Company buildings in the SE¼ and NE¼, Sec. 16, T. 19 S., R. 15 E.

Northward from Coalinga, Desmostylus (Sea Cow) teeth are common in the Miocene Temblor "Reef" section. Anadara (Arca), Pecten andersoni (Aequipecten), Scutella (a small sand dollar resembling (button), and Trophon (gastropod) have been collected from the "button" bed of the Temblor about 8½ miles north of Coalinga in the SW¼, Sec. 21, T. 19 S., R. 15 E. Ostrea titan has been collected from the lower Temblor in this same area.

The Miocene Santa Margarita Formation contains an extremely prominent fossil zone about 25-50 feet thick near its base. This zone is termed the Tamiosoma zone because of the presence of the prominent Tamiosoma gregaria (barnacle). Other prominent fossils of this zone include Ostrea titan (giant oyster) and Lyropecten

estrellanus (pelecypod). These fossils may be found in the NW corner of Sec. 22, T. 19 S., R. 15 E.

Typical fossils in the Miocene McLure Shale, member of the Miocene Monterey Formation, includes Miltha (a pelecypod), found on the west side of Tar Canyon in the SE¼, Sec. 7, T. 23 S., R. 17 E. Some fauna, similar to that found in the Santa Margarita Formation north of Coalinga, are found in Garza Canyon in the SW¼, Sec. 2, T. 23 S., R. 16 E. The McLure is relatively unfossiliferous in the Warthan Canyon area, southeast of Priest Valley.

Except for foraminifer, the Miocene Reef Ridge Member is relatively unfossiliferous.

The Pliocene Etchegoin Formation is extremely fossiliferous except at the base. This seems to indicate shallow, brackish water conditions and beach environments. Much crossbedding occurs in the middle and upper portions of the Pliocene Etchegoin-Jacalitos Formation.

The "Big Trophon zone", of the lower Pliocene Etchegoin-Jacalitos Formations, is typically exposed on the upper Jacalitos Creek area in SW¼, Sec. 6, T. 22 S., R. 15 E. The major fossils include Trophon, Macoma, Panopea, and Astrodapsis (a sand dollar with a "raised" star). This zone is also well exposed at the head of Garza Creek in Sec. 2, T. 23 S., R. 15 E.

A "Pecten estrellanus zone" is exposed on Canoas Creek in Sec. 27, T. 22 S., R. 16 E., and in Jacalitos Canyon in the NW¼, Sec. 33, T. 21 S., R. 15 E. The major fossils at these locations include: Lyropecten and Dendraster (sand dollar). The sand dollars are extremely numerous and are generally large and dark colored in the Jacalitos Canyon area.

A "Glycymeris zone" with the typical location southwest of Coalinga on State Highway 198 in the SW corner of Sec. 7, T. 21 S., R. 15 E. This zone was originally considered to be the base of the Pliocene Etchegoin Formation. Typical fossils include Glycymeris coalingensis, Diplodonta, Cardium, and Patinopecten. Lunatia (gastropod) may also be found on occasion.

The Big Blue Hills north of Coalinga, extending from Oil City northwesterly through Cantua Creek to the Ciervo Hills is unfossiliferous expect for Merychippus (horse teeth) found on the Domengine Ranch in the SW¼, Sec. 28, T. 18 S., R. 15 E.

An extensive array of the previously listed fossils and mammals such as beaver teeth, mastodon bones and teeth, horse teeth, camel, and deer bones are found southeast of Coalinga in the Kettleman Hills area.

Oil Fields

The townsite of Coalinga has five oil fields within the immediate vicinity.

FIELD NAME (ACREAGE)	1ST YR OF PRODUCTION (PEAK YR)	TOTAL CUM (& 1990) BARRELS OF OIL PROD	TOTAL CUM (& 1990) mmcf OF GAS	WELLS PRODUCING SHUT-IN ABANDONED	FORMATIONS PRODUCED
Coalinga (10,718 ac)	1887-1912 (1986)	772.5 million (11.5 million)	225,889 mmcf (none)	2101 prod 1314 S/I 2112 aban	Pliocene Etchegoin to Cretaceous
East Coalinga Extension (2425ac)	1939-1952 (1954)	500.5 million (847,000)	371,380 mmcf (17,501 mmcf)	73 prod 96 S/I 77 aban	Miocene Vaqueros to Eocene Gatchell
Pleasant Valley (500ac)	1943 (1960)	13.3 million (8175)	12,173 mmcf (3 mmcf)	1 prod 5 S/I 25 aban	Eocene Gatchell
Guijarral Hills (2300ac)	1948-1962 (1962)	49.1 million (17,957)	76,442 mmcf (6 mmcf)	2 prod 96 S/I 39 aban	Miocene Temblor to Eocene Gatchell
Jacalitos (2500ac)	1941 (1949)	21.9 million (64,407)	26,951 mmcf (21 mmcf)	23 prod 97 S/I 39 aban	Pliocene Etchegoin to Miocene Temblor

TABLE # 2. Coalinga Area Oil Fields. California Division of Oil and Gas.

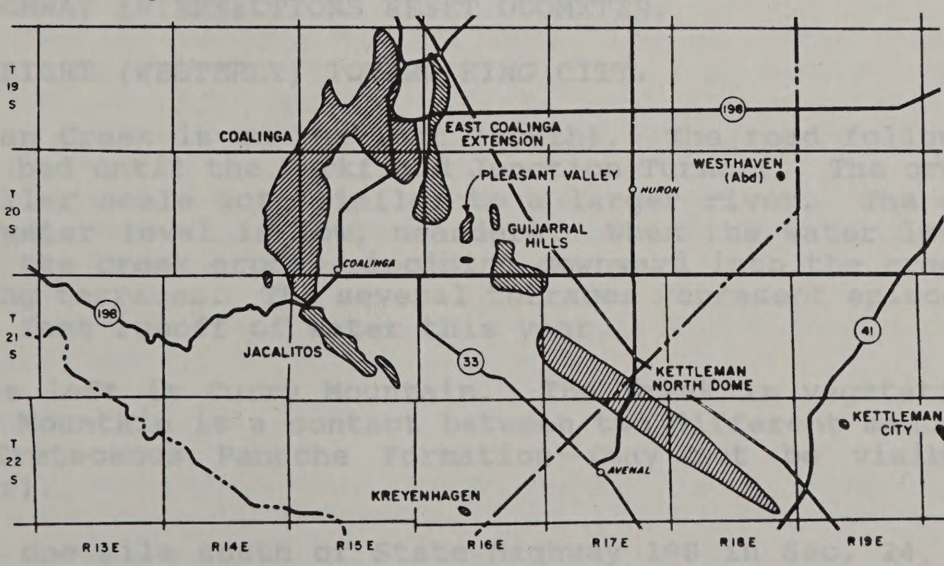


FIGURE # 1. Location Map of the major oil fields in the Coalinga Area. California Division of Oil and Gas.

LEAVING THE MUSEUM, PROCEED SOUTHWESTERLY ALONG ELM STREET (HIGHWAY 198) TOWARDS KING CITY.

0.3 FIRESTONE ROAD INTERSECTION. TURN RIGHT (WEST). The hills to the west are in the Pliocene Etchegoin Formation.

1.1 A turbidity structure is on right (north). (Turbidities are a sediment deposited from a turbidity current, a bottom flowing current laden with suspended sediment. It is characterized by graded bedding, moderate sorting, and well-developed primary structures, especially laminations.)

1.4 STOP # 2. COALINGA SULPHUR BATHS & PLUNGE.

The owner of this property, Craig H. Lewis, has given this group permission to visit here with the condition that all members of the group stay on the road and do not touch anything.

The baths were started in 1912 with an exploratory oil well that produced 2000 barrels a day of hot (118°F) water instead of the hoped for oil. Mr. Lewis took over the enterprise in 1934. At that time until the early 1940's a 4-foot tall flame of gas was flared over the well which supplied the bath. The large pipe on the east side was a hot water shower.

The oil derrick, downed in a winter storm in early January, 1993, is named the Coalinga Sulphur Bathes & Plunge # 1 and was drilled by Mr. Lewis. The drillers were unable to control the water and the well was abandoned. The baths and plunge are set in the Pliocene Etchegoin Formation.

RETURN TO HIGHWAY 198.

2.8 AT HIGHWAY INTERSECTIONS RESET ODOMETER.
/0.0

TURN RIGHT (WESTERLY) TOWARD KING CITY.

1.1 Warthan Creek is on the left (south). The road follows the creek bed until the Parkfield Junction Turnoff. The creek at a smaller scale acts similar to a larger river. The creek, when water level is low, meanders. When the water level is high, the creek erodes, incising downward into the creek bed forming terraces. The several terraces represent episodes of heavy fast runoff of water this year.

2.6 To the left is Curry Mountain. The break in vegetation on Curry Mountain is a contact between two different members of the Cretaceous Panoche Formation (may not be visible in winter).

About one mile south of State Highway 198 in Sec. 24, T. 21 S., R. 14 E. was the location of the forty acre Montford Marl

deposit. Close to a rail spur, in the 1880's lime was made from a 'vein' of limestone 12 feet wide which extended across the forty acres. This limestone contained a small amount of bituminous matter.

4.3 Located to the right (northwest) at the large curve, Oak Flat Canyon is in two members of the Cretaceous Panoche Formation. The canyon floor is the conglomerate member. The canyon walls are in the shale member. The canyon was formed in the shale member. As the canyon deepened, it eroded into the conglomerate member.

6.0 Warthan Creek has good exposures of the Cretaceous Panoche Formation to the right (north). A fault is in the roadcut.

7.5 Narrows at Juniper Ridge are across the Warthan Creek bridge to north. Curry Mountain, to the south, is on the upthrown side of thrust fault.

Beyond Curry Mountain the hills with lower relief are the younger Pliocene Etchegoin and Quaternary (Recent) landslides.

Five miles south of Curry Mountain was the location of the Carey Creek coal prospect in Sec. 16, T. 22 S., R. 14 E. It was prospected in 1894, when a landslide covered the prospect cut. After the slide an adit was started to open the coal vein in another place. This work was soon abandoned.

8.8 Parkfield Grade Road is to the left. To take a side trip to Parkfield, the "Earthquake capital of the world", go south on this road 19 miles. The road is roughly graded, not paved.

Long Hollow Valley goes northwest (right) from this point.

11.4 TURN RIGHT ON COALINGA MINERAL SPRINGS ROAD. This road goes to the right (northwest) towards the Coalinga Mineral Springs along Hot Springs Canyon. To the east are sandstone beds striking east and west of the Pliocene Etchegoin Formation.

Go north up Hot Springs Canyon Road. This canyon is very straight, and suggests the presence of a fault. This canyon parallels the San Andreas Rift Zone.

12.1 In the creek bed are the same features found in the larger Warthan Creek.

12.4 Cattleguard.

12.6 The conglomerate to the left (west) is a lower member Cretaceous Panoche Formation. At this point, an unnamed thrust fault is crossed.

13.0 The sandstone at the right across the small concrete bridge is a member of the Cretaceous Panoche Formation.

14.4 Markland Canyon is to the right (north).

14.5 Cattleguard.

14.7 At this point, is a good exposure of the Cretaceous Panoche Formation. This outcrop is a representation of a transgressive sequence.

The sequence is: upper part - shale, then middle part - sandstone, then lower part - conglomerate.

(Transgression is a change that brings offshore, deep-water environments to areas formerly occupied by nearshore shallow-water conditions. Shale, a very fine grained (1/16th millimeter or smaller in size (one inch equals 2.54 centimeters)) sedimentary rock, can be deposited when formed in deep-water environments (average is the 6400 foot (4000 meter) depth). Sandstone, a coarse grained (2 millimeter or smaller in size) sedimentary rock, can be deposited and formed in the transitional zone from shallow- to deep-water. Conglomerate, a pebble size and larger (over 2 millimeter in size) sedimentary rock, can be deposited and formed in shallow-water (average is up to several hundred meters in depth).

16.6 STOP # 3. COALINGA MINERAL SPRINGS.

This site was private property until it was deeded to the State of California who then deeded it to Fresno County. The homes at the park entrance are located on private lands. The land to the north of the park belongs to the United States government land, and is administered by the Bureau of Land Management.

The resort property was once owned by the prominent Kreyenhagen family for many years. The resort with its large hotel began operations in the 1880's. The hotel, on the flat area, and the hot springs, on the hillsides, were in operation until several years ago when the hotel burned down and all operations were ceased. In the early days, the springs were known as Fresno Hot Springs.

There are 15 different springs or seepages supplying water from the hillside above the park floor. Most of the springs were cemented in, with six being used to supply water for the resort area. The water from the hot springs in the resort was not hot enough naturally and was heated in the boilers located on the hillside to the west.

RETURN TO HIGHWAY 198 BY THE SAME ROAD.

17.1 A large Cretaceous Panoche Formation conglomerate member is on the ridge to the left (east).

19.2 This outcrop exhibits a flysch sequence of shale and sandstone. (A flysch is a marine sedimentary facies characterized by a thick sequence of poorly fossiliferous, thinly bedded, graded marls and sandy and calcareous shales and muds, rhythmically interbedded with conglomerates, coarse sandstones, and graywackes.)

19.4 Cattleguard.

21.3 Cattleguard.

22.3 /0.0 MINERAL SPRINGS ROAD AND HIGHWAY 198 (WARTHAN CANYON ROAD).

RESET ODOMETER.

TURN RIGHT, GO WEST TOWARD KING CITY.

In this township, along several miles the south side of Warthan Creek, was the location of the Warthan Creek coal prospects. Two seams, one 3 feet and one 1½ feet thick were superficially prospected. No production was recorded.

Five miles south of State Highway 198 in Monterey County was the site of the Stone Canyon Coal Mine. The Stone Canyon Coal deposit contains some of the highest rank coal in California, being classed as a high-volatile bituminous type. This deposit was discovered in 1870 and worked intermittently until 1935. Production was over 300,000 tons. The abandoned mine workings are flooded and caved. The coal seam is one of thickest in California, as much as 18 feet with an average thickness of 12 feet. Estimated reserves of the coal in place are over 700,000 tons. Overlying and underlying the coal seam is the Miocene Temblor Formation.

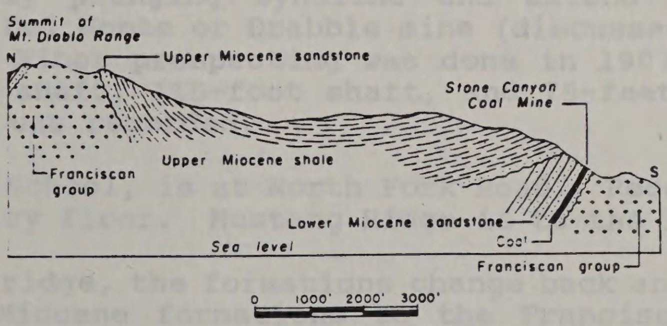


FIGURE # 2. Geologic Cross Section of Stone Canyon Coal Mine. (Hart, 1960, California Division of Mines and Geology)

1.9 The white rock units are in the younger Pliocene Etchegoin Formation. The topography is low. Warthan Creek, which turned south at the Parkfield Junction Road rejoins State Highway 198 to the left (south). In the approach to this unit, the Warthan Canyon Fault was crossed. The Warthan Canyon Fault is a thrust fault and division between the older Cretaceous Panache Formation thrusting over the younger Pliocene Etchegoin Formation.

6.6 Frame Road.

About two miles north of State Highway 198 was the location of another mineral springs called Mother Green's Ball Mountain Mineral Springs in Sec. 24, T. 20 S., R. 12 E. Bottled water from this spring was sold in the 1940's.

Adjacent to State Highway 198 in Sec. 26, T. 20 S., R. 12 E., was the coal mine, Del Monte or Drabble mine. Sixteen miles west of Coalinga at an elevation of about 2400 feet, this mine was worked by adits, the lowest of which was 390 feet long in 1896.

The source of Warthan Creek is to the left (south) within a half mile. The summit is actually a water divide. All the streams have been flowing to the east, the San Joaquin Valley. All the streams to the west of the divide flow to the Salinas River and onto the Pacific Ocean.

9.8 Monterey County Line.

10.0 Priest Valley, a valley which parallels the San Andreas Fault Zone located to the west.

Just north of State Highway 198 are the Priest Valley coal prospects. Thin Coal seams occur in carbonaceous shale beds and interbedded sandstone that are equivalent to the Pliocene Etchegoin and Jacalitos Formations. The coal beds crop out as a southeasterly plunging syncline and extend into Fresno County to the Del Monte or Drabble mine (discussed at mileage marker 6.6). Minor prospecting was done in 1907 with a 60-foot inclined shaft, 115-foot shaft, and 75-feet of drifts. No production was recorded.

13.2 Priest Valley School, is at North Fork Road. Recent alluvium is on the valley floor. Mustang Ridge is to the left (west).

Ascending the ridge, the formations change back and forth from the Pliocene-Miocene formations to the Franciscan Melange. The formation boundaries are parallel faults to the San Andreas.

Recent storm damage is visible in the roadsides, hillsides, and along the stream bed.

15.0 A serpentine outcrop of the Franciscan Melange is in the road-cut to right (north).

15.3 Overlook of North Fork Lewis Creek and Mustang Ridge. The San Andreas Rift Zone is to the west just over the Mustang Ridge summit.

16.0 A green serpentine outcrop, part of the Franciscan Melange, is to the right (north).

16.2 The road cuts are through the Cretaceous Panoche Formation.

17.4 A gravel pit is on the right (north). Called the Mee Ranch pit, the material of the pit was from sheared and weathered chert and greenstone deposits of the Franciscan Melange. Modern day road material is stored at this site.

17.5 The San Andreas Fault Zone is located right below the summit of Mustang Ridge.

North of the State Highway on the Mee Ranch is a chromite deposit associated with the serpentine of the Franciscan Melange. The chromite which reportedly ran 53.6% chromite with a 3:1 Cr/Fe ratio, occurs in boulders weighing as much as several tons. Bright green uvarovite, a chromium-bearing garnet, is associated with this ore.

18.5 STOP # 4. TURNOUT ON THE LEFT SIDE OF THE ROAD.

Overlook of San Andreas Fault Zone. The San Andreas Rift Zone extends from the west side of Peach Tree Valley to Mustang Ridge, where we are standing. The current active trace of the zone is several hundred feet in front of our location just below the sag pond. Other characteristics of the fault in this area are the sag ponds, a linear valley, pressure ridges, trenches, offset streams and fences, springs, and landslides.

Across the Peach Tree Valley is a flat area above the stream that represents a former valley floor is called a river terrace. An eroded river terrace is just downhill from this stop point. The increased drainage is cutting into the present valley floor.

The rocks with the graffiti at this location are chlorotic sandstones and shales associated with the Franciscan Melange. The rocks have experienced low-grade (greenschist) metamorphism.

San Andreas System

The San Andreas Fault Zone has a total length of 740 miles (1200 kilometers) of which over 600 miles (960 kilometers) are located in western California. On land the fault extends south from Shelter Cove in Humbolt County, through Daly City, the Coast Ranges, the Carrizo Plain, around the 'Big Bend' at Frazier Mountain, through to the Salton Sea in the southeastern part of the state, and on into the Gulf of California. Consisting of a series of parallel faults, the zone is from several hundred yards to a few miles wide. The San Andreas is classified as a right lateral strike slip fault. No matter which side of the fault you are positioned, the fault's motion is to the right.

History

Before the advent of the San Andreas Fault system, the North American Plate and the Farallon-Pacific Plates were adjacent to each other. (The remnant Farallon Plate, now called the Juan de Fuca Plate, is located off the coast of Oregon-Washington.) Each of the two plates formed continental lithosphere at mid-ocean ridges with the subduction of the Farallon-Pacific Plates occurring beneath the North American Plate. As the subducted crust descended beneath the trench, it was attached to the accretionary forearc slope basin (Franciscan Melange). The remnant forearc basin is the Great Valley sequence. The eroded arc massif (root zone of the former volcanic arc) is the Sierra Nevada batholith.

As the subduction of the Farallon Plate occurred faster than the continental lithosphere was created, the Farallon-Pacific Plates spreading center was swallowed by its own trench. The subduction of the spreading zone began at the Mendocino Triple Junction, when the zone was located near Los Angeles. The junction has since migrated to the north as more of the spreading center was subducted. The transform strike-slip San Andreas Fault is the boundary of the former spreading center-trench system.

In the early 1890's a geologist, Andrew Lawson, sailed from Los Angeles to San Francisco. By observing the linear nature of the coastline, he arrived at the conclusion that faulting was a major structural feature within the state. In 1895, Lawson applied the name, San Andreas, to a recognized fault zone containing San Andreas Lake located south of San Francisco. Within the state, other names were used for various other segments of this same fault. It wasn't until after the 1906 San Francisco earthquake that the San Andreas Fault was recognized as a continuous regional structure of major importance and the name was applied to the entire zone. The mismatch of adjacent sides of the San Andreas Fault was thought to be because of vertical displacement. Horizontal displacement was calculated to be from 1 mile (1.6 kilometers) to 25 miles (40 kilometers).

FIGURE # 3. California in early Cenozoic. (Dibblee, 1989)

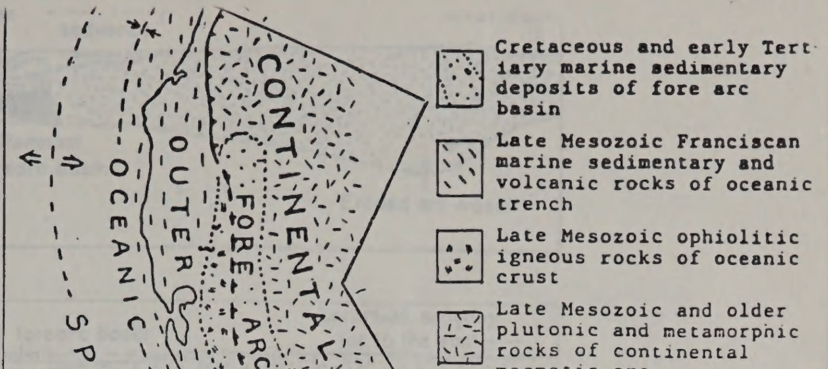
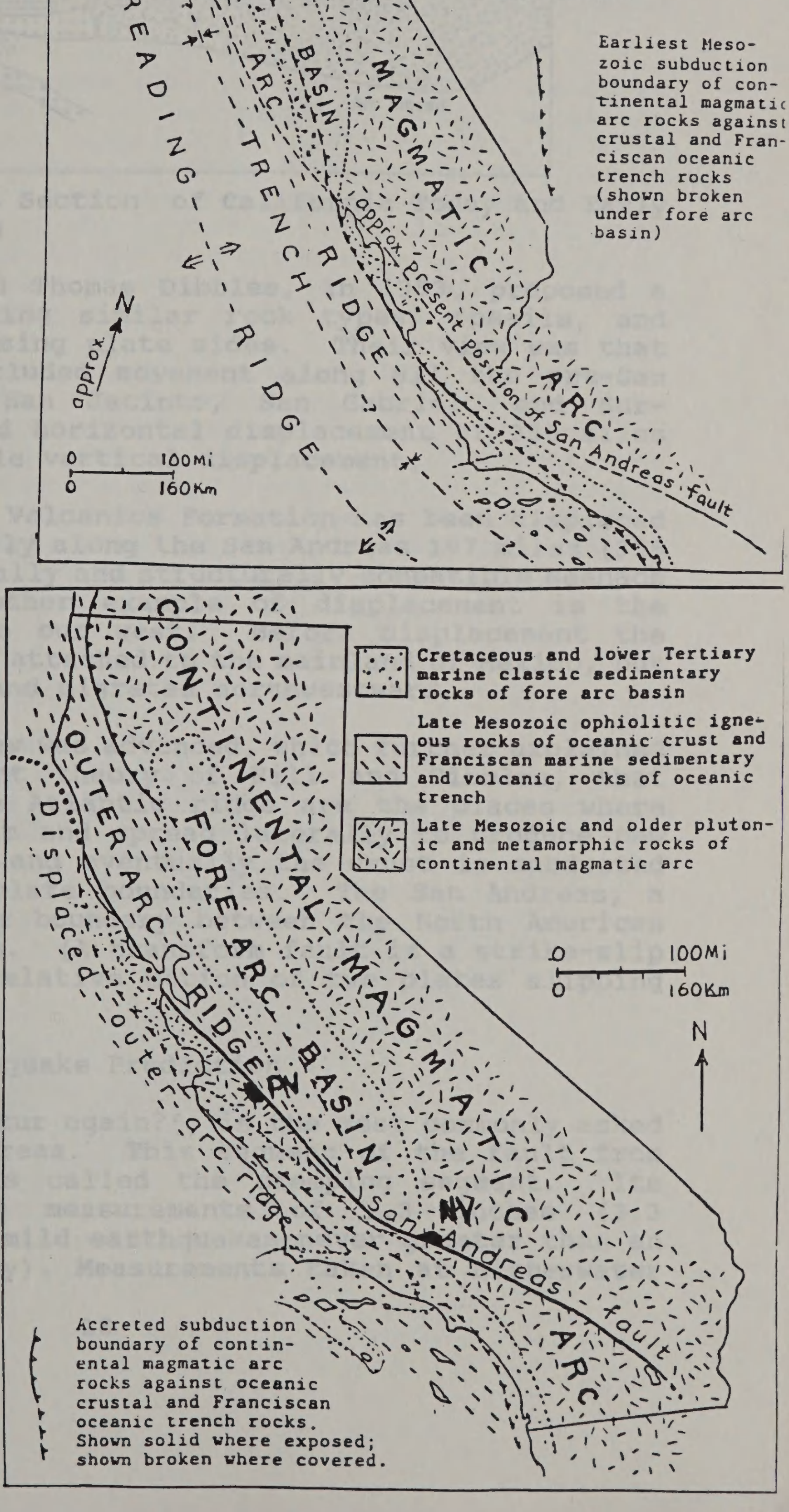


FIGURE # 4. California in today, displaced northwestward on the south side (Pacific Plate) in respect to the North American Plate. (Dibblee, 1989)



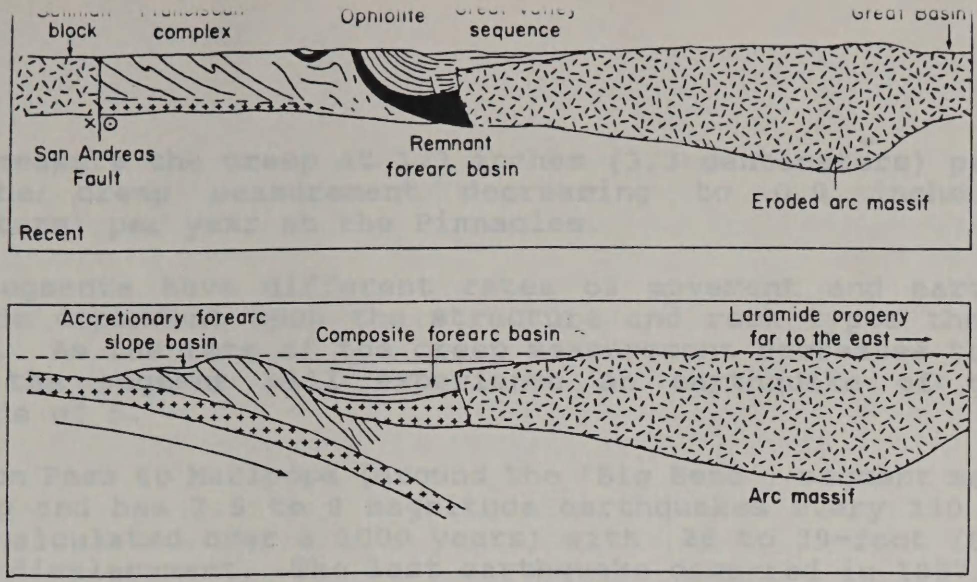


FIGURE # 5. Geologic Cross Section of California Today and Early Cenozoic. (Matthews, 1984)

Geologists, Mason Hill and Thomas Dibblee, in 1953, proposed a hypothesis based on matching similar rock types, fossils, and structures of the two opposing plate sides. Their view was that the San Andreas (this included movement along all the pre-San Andreas Faults-Elsinore, San Jacinto, San Gabriel, and Sur-Nacimiento) has experienced horizontal displacement of 350 miles (560 kilometers) with little vertical displacement.

For example, the Pinnacles Volcanics Formation has been displaced to the northwest horizontally along the San Andreas 197 miles (315 kilometers) from the chemically and structurally compatible Neenach Volcanics Formation. Another example of displacement is the Salinian Block adjacent to our west. Before displacement the 'exotic' Salinian block was attached to the mainland of Mexico, but through time was detached and migrated northwestward.

In the early 1960's, the view was advanced, which further explained the horizontal displacement theory of Hill and Dibblee, that midoceanic ridges like the Atlantic ridge are the places where magmas rise from the mantle and spread laterally to produce new oceanic/continental crust, and eventually the crust is subducted into trenches located at plate boundaries. The San Andreas, a transform fault, is on the boundary between the North American Plate and the Pacific Plate. (A transform fault is a strike-slip fault that describes the relative motion of two plates slipping past one another.)

Earthquake Prediction

'When will an earthquake occur again?', is the most commonly asked question about the San Andreas. This segment of the fault from here north to Hollister is called the creeping segment. Its characteristics are creep measurements of 1.3 inches (3.3 centimeters) per year with mild earthquakes never greater than an magnitude of 5 (1993 Gilroy). Measurements taken at Bitterwater

Valley measure the creep at 1.3 inches (3.3 centimeters) per year with the creep measurement decreasing to 0.9 inches (2.3 centimeters) per year at the Pinnacles.

Fault segments have different rates of movement and earthquake magnitude dependent upon the structure and rock types the fault bisects. As the rate of the creep measurement decreases the more likely the segment will experience an earthquake of greater magnitude of 5.

The Cajon Pass to Maricopa (around the 'Big Bend') segment measures no creep and has 7.5 to 8 magnitude earthquakes every 130 to 185 years (calculated over a 1000 years) with 26 to 39-foot (8 to 12 meters) displacement. The last earthquake occurred in 1857 and it is estimated that 24 feet (7.2 meters) of strain has accumulated. South of our location, in a straighter part of the fault near Parkfield, earthquakes occur in the magnitude of 6 every 20 to 32 years (1966 Parkfield). Creep is measured at the rate of inches 0.6 inches (1.5 centimeters) a year.

The San Andreas Fault as it slides northwestward into the Aleutian Trench is being overridden by the westward moving North American Plate. The 350-mile measurement of movement has come from the combined movements of the pre-San Andreas Faults (Elsinore, San Jacinto, San Gabriel, and Sur-Nacimiento) as well as the current trace of the San Andreas. As it has in the past, it is expected future motion of the plates occur further to the east-'maybe Landers?'-'Furnace Creek?'-'Las Vegas shear zone?'.

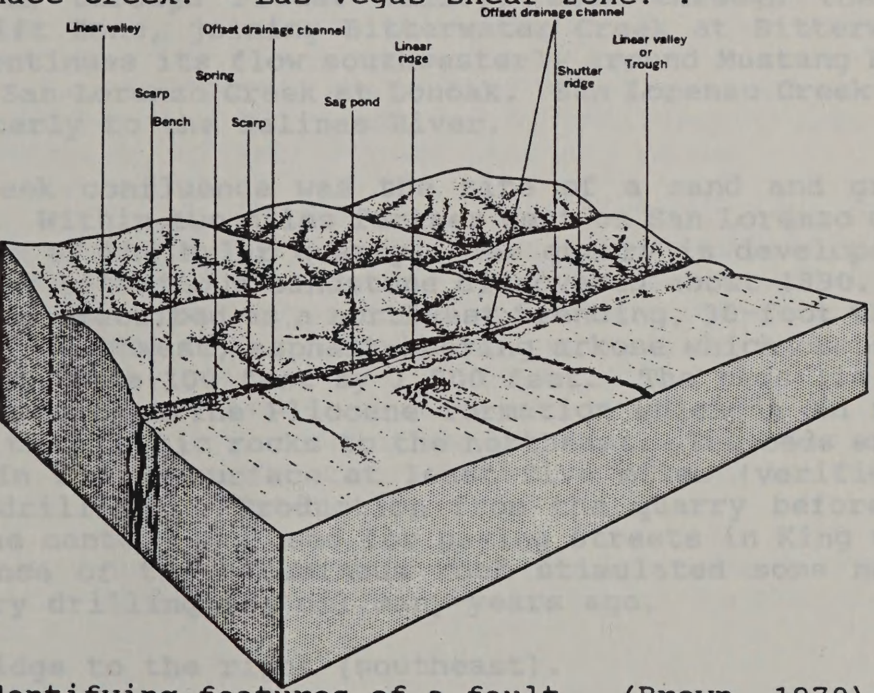


FIGURE # 6. Identifying features of a fault. (Brown, 1970)
19.3 A sag pond is to the left (south).

19.6 Landslides on the hillsides are toward the top of the hills to right (north). Landslides are earth and rock loosened by the constant shearing, crushing movement of the San Andreas Fault Zone.

21.5 Gravel exposures are in the roadcut.

22.0 INTERSECTION OF STATE HIGHWAY 198 AND HIGHWAY 25.

TURN RIGHT (NORTH) TO THE PINNACLES (33 miles).

In Peach Tree Valley on both sides of State Highway 25, the formation is the marine Pliocene Pancho Rico. This unit underlies and is unconformable with, but is similar to the non-marine Pleistocene Paso Robles Formation. San Lorenzo Creek is to the left (west).

(Unconformable is defined as not succeeding the underlying strata in immediate order of age and but is parallel position.)

31.7 Lonoak. Stay on paved main road. Go north toward the Pinnacles.

Just before Lonoak is the confluence (point where two streams meet) of Lewis Creek into San Lorenzo Creek is to the left (west). Lewis Creek flows from the other side of Mustang Ridge north through Priest Valley, then through the San Andreas Rift Zone, joining Bitterwater Creek at Bitterwater Valley, continues its flow southwesterly around Mustang Ridge and joins San Lorenzo Creek at Lonoak. San Lorenzo Creek then flows westerly to the Salinas River.

At the creek confluence was the site of a sand and gravel operation. Within two miles further west on San Lorenzo Creek is the site of the Mylar quarry. The quarry is developed on a deposit of bituminous sandstone discovered about 1890. The sandstone is described as a northwest trending, 30-foot thick, dipping 14° southwest, asphalt-bearing arkose which crops out over an area some 100 feet by 1,500 feet. The beds lie in a basal part of a marine Pliocene formation which is in fault contact with granitic rocks to the northeast. The beds extend to south in the subsurface at least five miles (verified by oil well drilling). Production from the quarry before the turn of the century was used for paving streets in King City. The presence of the bituminous rock stimulated some nearby exploratory drilling for oil many years ago.

Mustang Ridge to the right (southeast).

33.9 Confluence of Lewis Creek with Bitterwater Creek at the San Benito County Line. Head north into Bitterwater Valley.

34.5 Lewis Creek Road. The hills are the Pliocene Pancho Rico formation of a diatomaceous mudstone.

San Andreas Fault Zone on side of hill to the right (east) is at the break in slope. The smooth triangular shaped frontage of the hills between the stream drainages are called triangular facets. (A triangular facet is hill located between drainages that appears cut off in the shape of a triangle. The fault is at the base of the triangle.) The fault separates the Pliocene Pancho Rico Formation from the Pliocene Etchegoin Formation.

The brown massive unit is a sliver of Franciscan Melange in the fault zone.

To the west is the location of the Monterey Gypsum Company gypsum deposits. Produced off and on since the 1890's, the gypsum is found in flat-lying lenses 4- to 6-foot thick covered by 4- to 8-foot of overburden. The gypsum is sold for agricultural use.

34.7 San Benito County Line.

40.5 The sag pond in Bitterwater Valley is normally dry, but in wet weather, its size increases to about a half mile across.

41.2 STOP # 5. LUNCH STOP. Our hostess for today is Cynee O'Connor and family. It is a yellow house behind another house. This is a private residence.

The San Andreas is located at the valley edge on the eastside. Evidence of the presence of the fault are offset fences, trenches, linear soil boundaries, offset streams, and sag ponds.

The Bitterwater Oil Field, at the north end of Bitterwater Valley along the San Andreas Fault Zone, consisting of 70 acres, was discovered in May, 1952. Production is from the Pliocene Etchegoin to Miocene Bickmore Canyon Arkose Formations. Average well depths 1567 feet. In 1990, the field's cumulative production was 311,736 barrels of oil (3611 barrels of oil in 1990) from 26°API with no natural gas production. Peak oil production occurred in 1952. Currently the field has 11 producing wells and 3 abandoned wells. Structurally the field is an elongated dome truncated by the San Andreas Fault Zone on the east.

41.6 Pliocene Pancho Rico Formation is on the left (west) side of valley and the Bitterwater School House is in the Pleistocene Paso Robles Formation.

41.9 Junction with the King City Road on State Highway 25. Go to the right and continue on State Highway 25.

42.6 San Andreas Fault Zone at the base of the hills to the east.

43.9 RESET ODOMETER AT THE COALINGA ROAD INTERSECTION.
/0.0

OPTIONAL SIDE TRIP

The road to the right goes through the New Idria Mining District and ends in Coalinga. The New Idria Mining District and its mining activities relating to mercury and asbestos were discussed in Coalinga.

For the first mile, the Coalinga Road follows the San Andreas Fault Zone. Typical examples can be seen of offset streams, offset fences, linear soil boundaries, and scarps. The hills to the east are the Pliocene Etchegoin Formation. The zone itself is within the Franciscan Melange and the Cretaceous Gravely Flat Formation, the dark shale member.

0.1 A low pressure ridge is on the left (east).

0.7 The white farm home on the right sits on the San Andreas Fault Zone.

0.9 THE DIRT ROAD IS ON PRIVATE PROPERTY. OBTAIN PERMISSION BEFORE ENTERING THE PROPERTY.

The fence that parallels the dirt road is offset a few feet about sixty yards south of the power pole. San Andreas Fault's active trace is in the small lineal depression west of the power pole at the fence along the dirt road.

RETURN TO STATE HIGHWAY 25 AND COALINGA ROAD INTERSECTION.

1.8 RESET ODOMETER AT THE INTERSECTION.
/0.0

The state highway follows the San Andreas Fault Zone through Rabbit Valley. The white rocks are the Pleistocene Paso Robles Formation on the left (west) and the buff-cream rocks are the Pliocene Etchegoin Formation on the right (east).

2.8 An old water dump is on the left (west) side of the road.

The intersection at an almost 90 degree angle of Topo Creek to the linear Little Rabbit Valley.

Ahead is Dry Lake Valley. The depression on the left is usually a dry sag pond, unless a period of heavy rainfall occurs. Usually at least one border of the sag pond is a fault zone. If the fault is a sealing fault, water is unable to migrate through the fault zone and is retained in the pond. If not, the water drains underground into the surrounding ground.

8.7 The fault controlled, San Benito River parallels the San Andreas one mile to the east along the San Benito Valley.

9.7 Directly in front at the Summit are the Pinnacles.

11.0 The San Andreas Fault Zone is to the right (east) almost at the top of the ridge.

12.0 TURN LEFT (SOUTH) TOWARDS THE PINNACLES ON STATE HIGHWAY 146.

Bear Valley extends to the northwest and also to the south along Highway 146 into the park.

The road cuts through the Miocene terrestrial conglomerate of unsorted granitic detritus and minor rhyolitic detritus originally from the Pinnacles Formation.

13.0 The road cut exposes recent river sands and gravels.

14.0 The Pinnacles Camp Ground.

14.7 The Pinnacles National Monument Boundary.

15.5 Pinnacles day use area.

The National Park Service is deciding as this is being printed whether to waive the entrance fee for our group.

16.0 Visitor's Center turn off.

TURN LEFT, GO WEST UP BEAR GULCH TO THE CENTER. The Chalone Creek Fault, the eastern boundary of the Miocene Pinnacles (Neenach) Formation, is buried under the creek alluvium.

16.4 The Miocene Pinnacle (Neenach) Volcanics are in the roadcuts.

17.2 STOP # 6. VISITOR'S CENTER.

The Pinnacles are located in the south part of the Gabilan Range. This small area of rough and jagged topography is very conspicuous among the rolling grass-covered hills of this part of the Coast Ranges. It has been a popular attraction since the late 18th century. In 1794, George Vancouver, coastal explorer, took time to come by mule to the Pinnacles. The Pinnacles National Monument was established in 1908, and developed with trails by the Civilian Conservation Corps (CCC) in the 1930's.

Geology

The Pinnacles Formation is a thick sequence of rhyolitic pyroclastic deposits, chiefly volcanic breccia, with some tuff and

agglomerate. The formation was named for its exposure in the Monument, where it reaches a thickness of 2600 feet. The estimated total volume of the volcanic material originally erupted is 6-10 cubic miles (25-40 cubic kilometers). All but three cubic miles (12½ cubic kilometers) have been eroded. The original height of the tallest volcanic is estimated to be about 8500 feet (2580 meters) one mile higher than North Chalone Peak (elevation 3304 feet (1007 meters)) the tallest peak in the Pinnacles Volcanic Formation.

The Pinnacles are coarsely stratified, and consist almost entirely of angular fragments of rhyolite, both flow banded and massive, averaging one to three inches in diameter in a tuffaceous matrix. Loose rock fragments range is size from ash to blocks six feet in diameter. Some of the beds containing larger angular to rounded fragments could be called agglomerate. The formation has seven recognized members. In ascending order, these are the rhyolite member, the pumice lapilli-tuff member, the andesite member, the agglomerate member, the dacite member, the porphyritic rhyolite member, and the rhyolitic breccia member.

The geologic events of the volcanic sequence started with masses of rhyolitic lava erupting from at least five vents as flows from the older Santa Lucia quartz diorite. During the eruptions, the magma varied form andesitic and basaltic to mainly rhyolitic. Towards the end of the eruptive cycle, some of the vents became plugged, and periodic steam eruptions blasted out of the plugs. This formed the breccias which have remained in place as avalanche deposits. The final color of the formation was dependent on the amount and chemical content of the steam (water) present at the time of the eruption.

The Pinnacles Formation was overlain by the Miocene Monterey Formation and encased in a down faulted block about six miles (10 kilometers) long and 2½ miles (4 kilometers) wide. The fault on the westside of the block is the north-south trending Pinnacles Fault and on the eastside of the block is the northwest-southeast trending Chalone Creek Fault. The Chalone Creek Fault is generally interpreted as a early Miocene trace of the San Andreas Fault Zone. The blockfaulting preserved the volcanic formation within the older Santa Lucia Quartz Diorite of the Gabilan Range. Starting in the Pleistocene, the exposed volcanics were eroded by weathering, producing the jointed spires, crags, and steep cliffs seen today. In some places the joints have been enlarged into crevices, which have later been partially covered by large blocks tumbled from the cliffs on either side, to form caves.

Plate Tectonics

Similar geochemical and age characteristics have confirmed the correlation of three areas along the San Andreas at the Pinnacle

Volcanics, the volcanic rocks of Lang Canyon near Parkfield, and the Neenach Volcanics between Gorman and Palmdale. The eruptions occurred about 24 million years ago. The magmas were generated as the Mendecino triple junction migrated northward, and left behind a no-slab region that was filled by subcontinental mantle. This source may have recently been enriched in material from the passing subducted slab. Pressure reduction initiated melting to produce basalt which rose and interacted with the overlying crust to produce the more evolved rocks.

The Pinnacles are an excellent example of the measurement of horizontal displacement of the San Andreas Fault. Since the initial eruption of the common Pinnacles-Neenach Volcanics, the San Andreas has been offset about 197 miles (315 kilometers) from the Neenach rocks. The Lang Canyon volcanics near Parkfield, a sliver of the Pinnacles Volcanic Formation left behind as the fault migrated northwesterly, is displaced about 59.5 miles (95 kilometers) from the Pinnacles Formation and 137.5 miles (220 kilometers) from the Neenach Formation.

Mining Activities

Prior to the establishment of the Monument, most of the Pinnacles National Monument was located in the Melville Mining District. The active period of the district was from the 1870's to the 1920's. The lands within the Monument are withdrawn from mineral entry.

The largest mining activity took place at the Melville Mine located the SW¼, Sec. 33, T. 16 S., R. 7 E. at the western boundary of the Monument in the early 1880's. The old townsite of Palisade was in the SE¼ of the same section. No production records were kept, but various state mineral reports indicate the mine was worked for copper, silver, mercury ore, gold, and molybdenum. In 1921, the Melville Mine was surveyed and was found to be non-mineral in character.

About one mile south of the Bear Gulch Visitor's Center in the SE¼, Sec. 11, T. 17 S., R. 7 E., located about one quarter of mile apart were the Chalone and Defiance Claims. These gold claims were developed between 1890 and 1896. Two adits of 540 and 400 feet were developed on the claims before they were abandoned. No production was recorded. Mineral analysis, in the mine vicinities in the 1980's, reflected the presence of gold in the amount of 0.03 ounces per ton (to be profitable at today's prices, gold should be found in the amount of 0.20 ounces per ton).

About four miles south of the Bear Gulch Visitors Center, about 1914, gold was found in andesite rocks. Gold was also prospected and found in stream gravels located along Miner's Gulch to the southwest outside the Monument boundary. Prior to 1920, about four miles south of the Bear Gulch Visitor's Center, the Vancouver Pinnacles Molybdenum Company drove a 50-foot long adit in a

molybdenite-quartz vein. No mineral production was recorded.

About three miles to the northwest, near the western boundary of the Monument, was the location of the Copper Mountain Mine. Workings consisted of two 10-foot adits and two open cuts an obvious copper ore zone. No mineral production was recorded. A sample of the rock from this mine was analyzed in the 1980's. The sample indicated an enriched copper, lead, zinc, and arsenic content (a chemical pattern typical of epithermal gold and silver deposits related to calc-alkaline igneous rocks).

An analysis of the Pinnacles Volcanics indicate the formation to be a calc-alkaline volcanic series enriched in arsenic. Associated with the presence of arsenic is a higher than average potential for the presence of gold and silver deposits. A through analysis of the mineral potential was made by the United States Geological Survey in the 1980's. The result was that the Pinnacles Volcanic Formation has a low potential and source for gold and silver deposits.

END OF THE FIELD TRIP.

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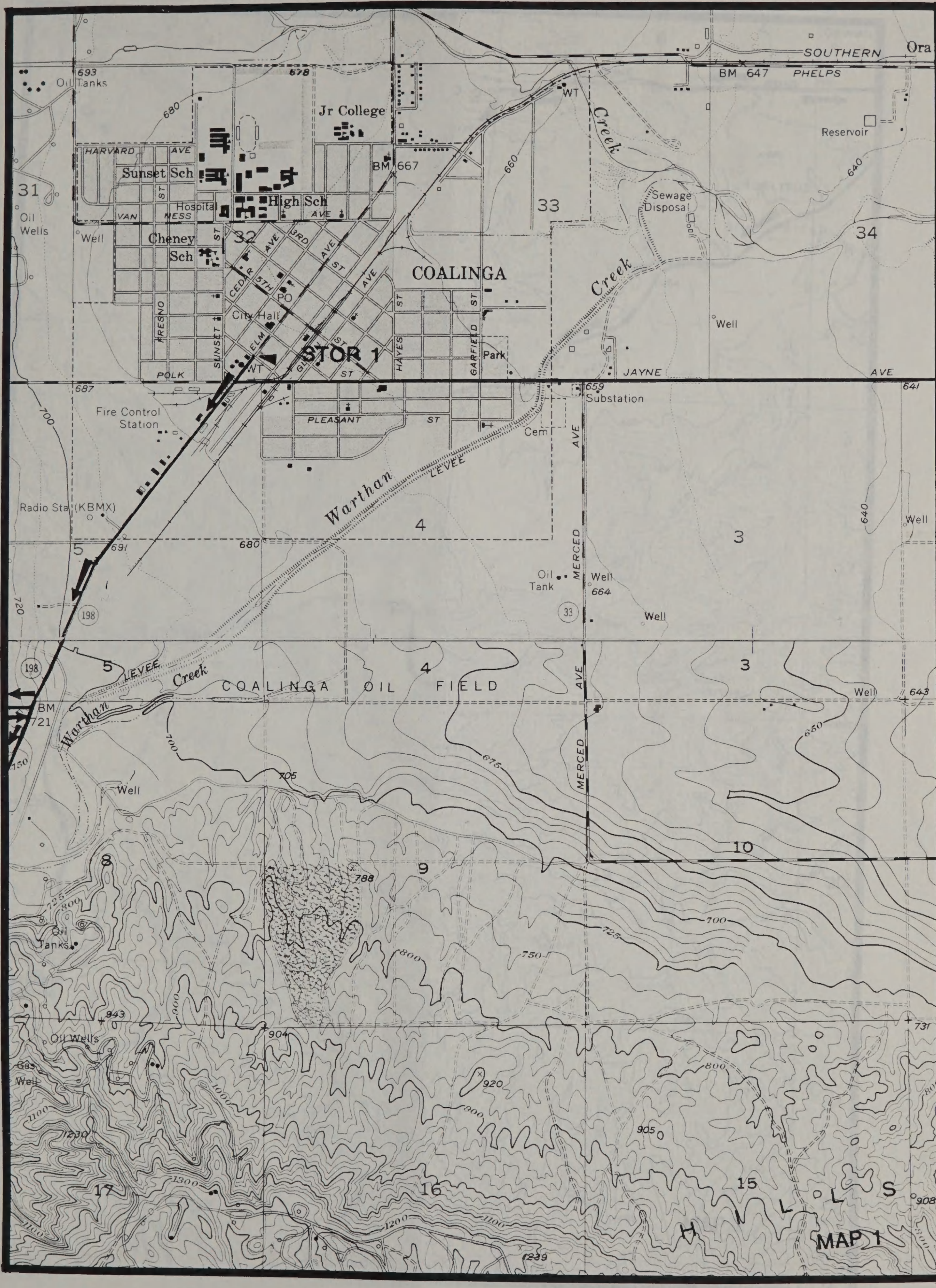

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Sunset Sch
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High Sch
Sewage Disposal
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Oil Wells
VAN NESS AVE
Cheney Sch
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Well
CEDAR
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AVE
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COALINGA
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City Hall
FRESNO
SUNSET ST
ELM
HAYES ST
GARFIELD ST
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Substation
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Fire Control Station
PLEASANT ST
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Warthan
LEVEE
Radio Sta (KBMX)
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680
MERCED AVE
Oil Tank
Well
664
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COALINGA OIL FIELD
BM 721
705
Well
643
Well
8
9
10
788
Oil Tanks
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Gas Well
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H I L L S
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MAP 1
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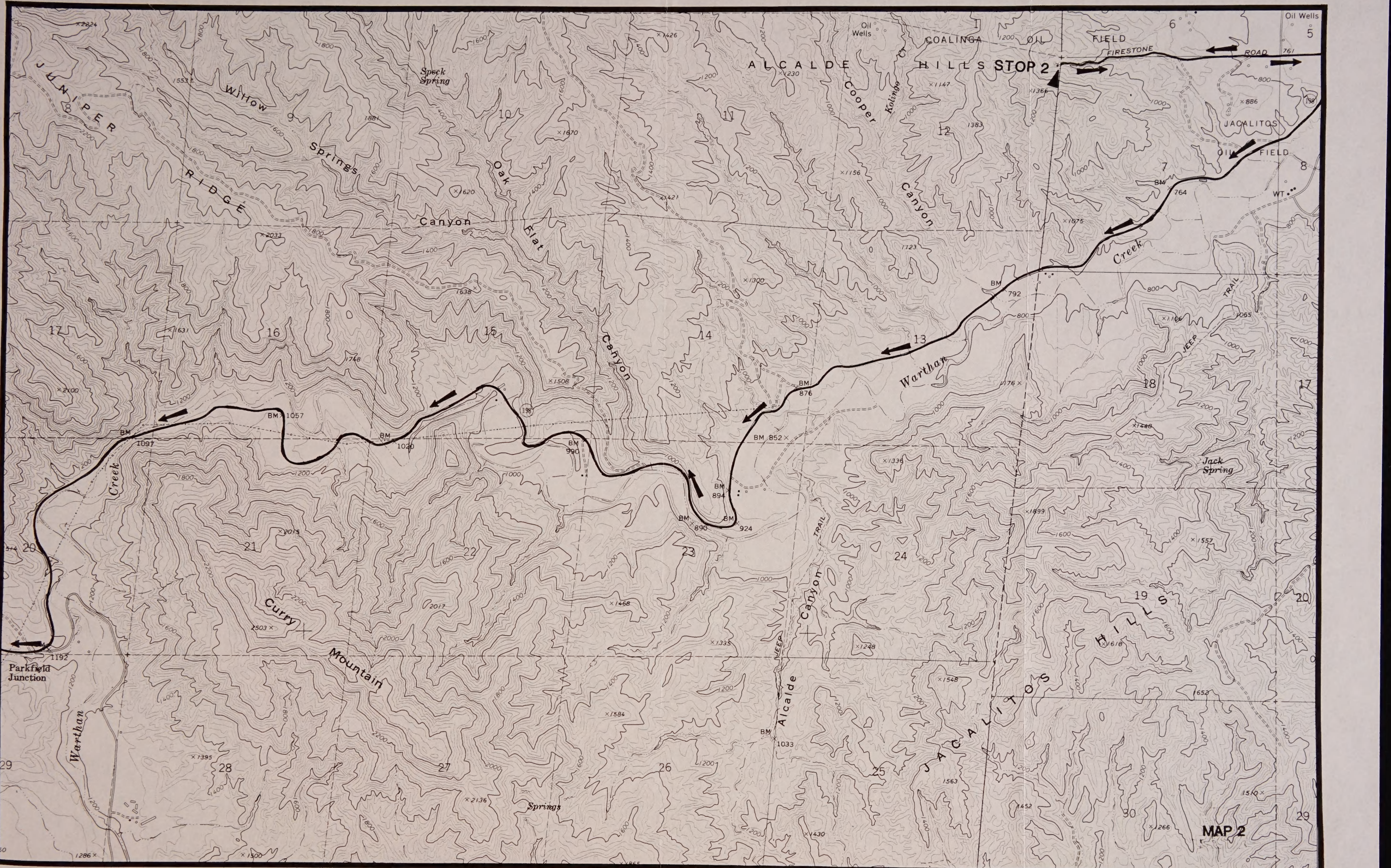
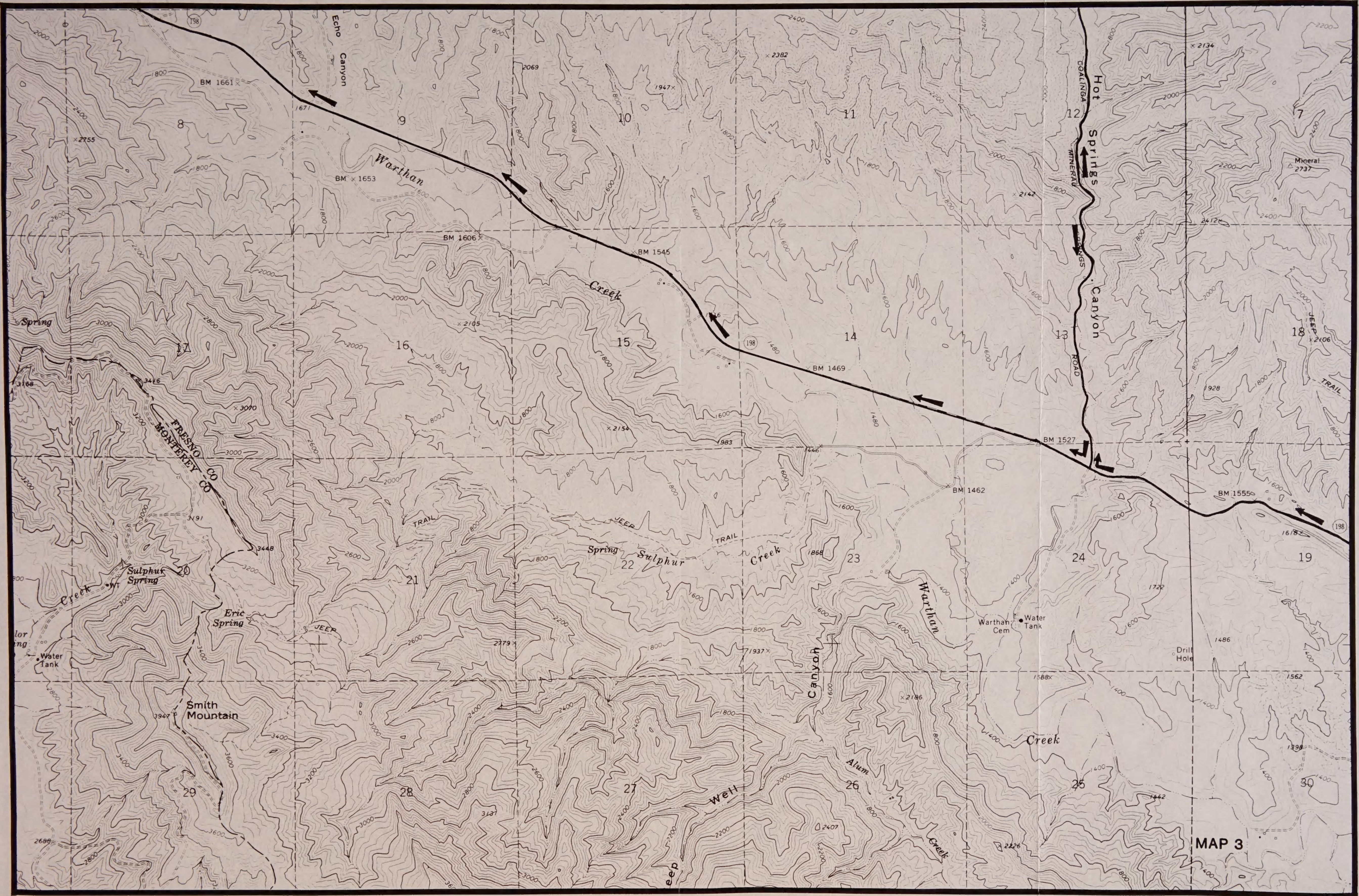

STOP 2
COALINGA OIL FIELD
FIRESTONE ROAD
ALCALDE HILLS
JACALITOS OIL FIELD
JUNIPER RIDGE
Willow Springs Canyon
Speck Spring
Oak Flat Canyon
Cooper Canyon
Kolinga Cr
Warthan Creek
JEEP TRAIL
Jack Spring
Alcalde Canyon
TRAIL
Curry Mountain
JACALITOS HILLS
Parkfield Junction
Warthan
Springs
Oil Wells
MAP 2


MAP 3
Echo Canyon
Warthan Creek
Hot Springs Canyon
COALINGA MINERAL SPRINGS ROAD
BM 1661
BM 1653
BM 1606
BM 1545
BM 1469
BM 1527
BM 1462
BM 1555
198
FRESNO CO
MONTEREY CO
Spring
Sulphur Spring
Eric Spring
Sulphur Creek
Spring
JEEP TRAIL
Water Tank
Smith Mountain
Warthan Cem
Drill Hole
Mineral
Alum Canyon
Well Creek
Creek
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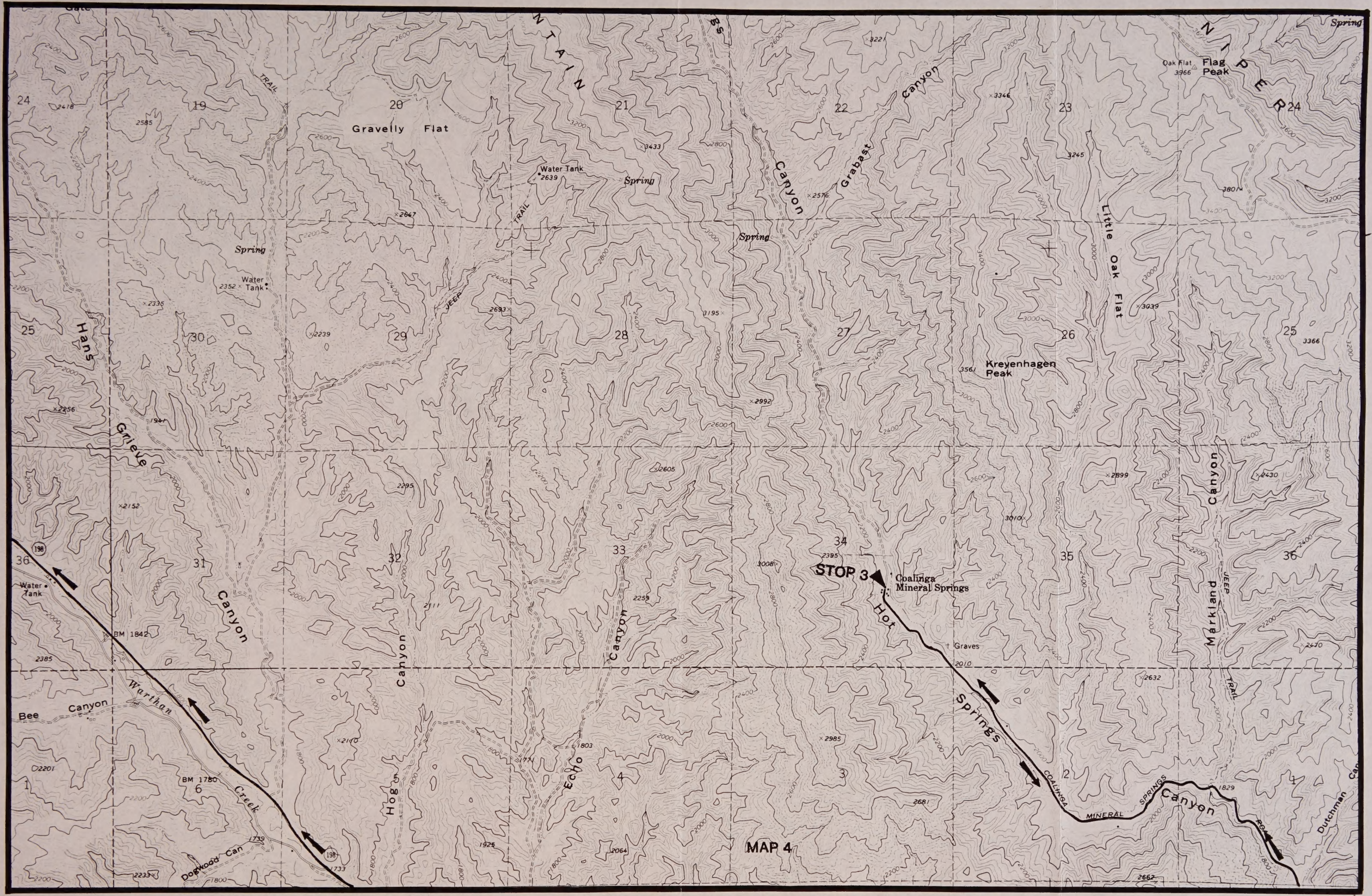
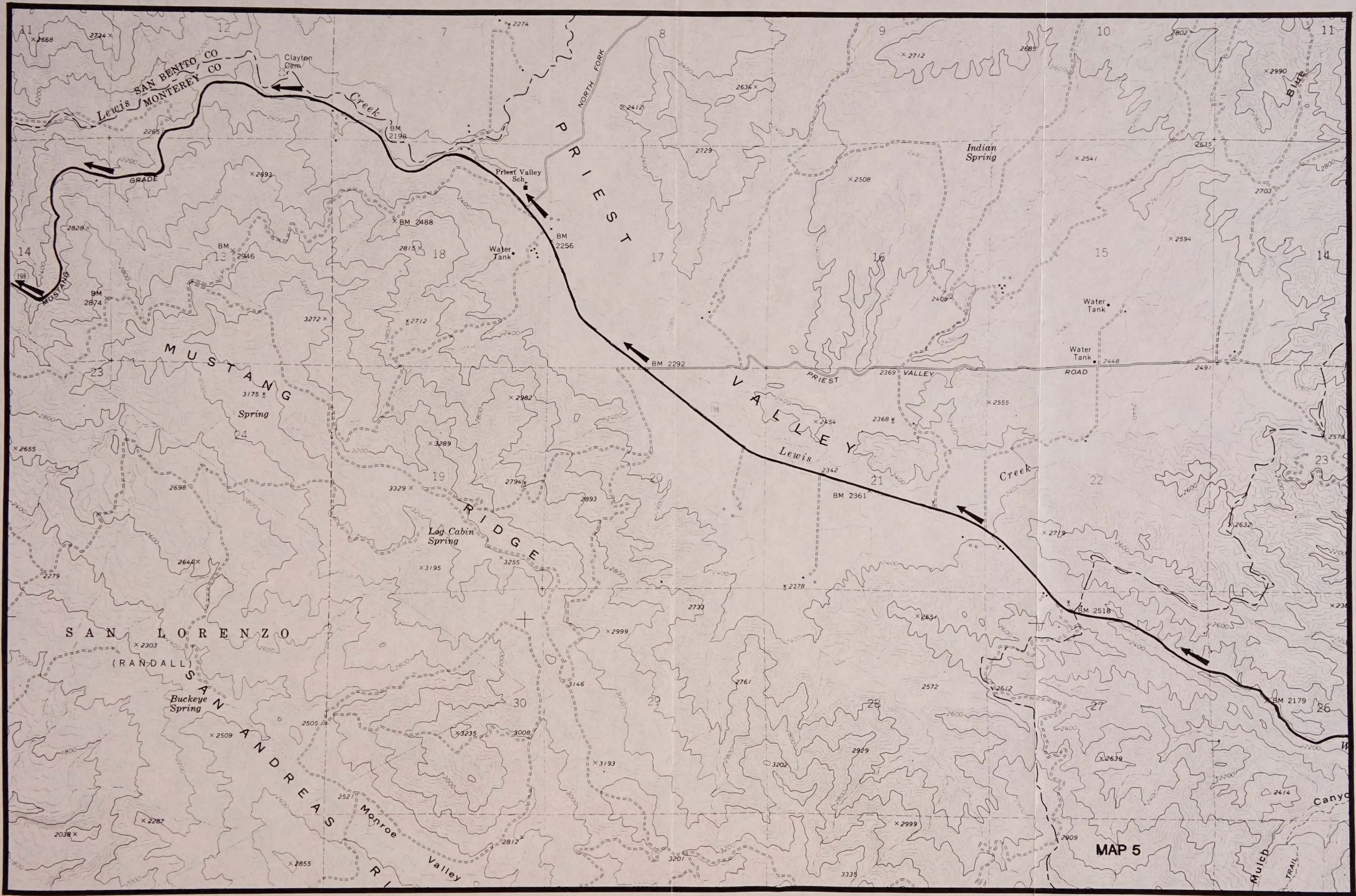
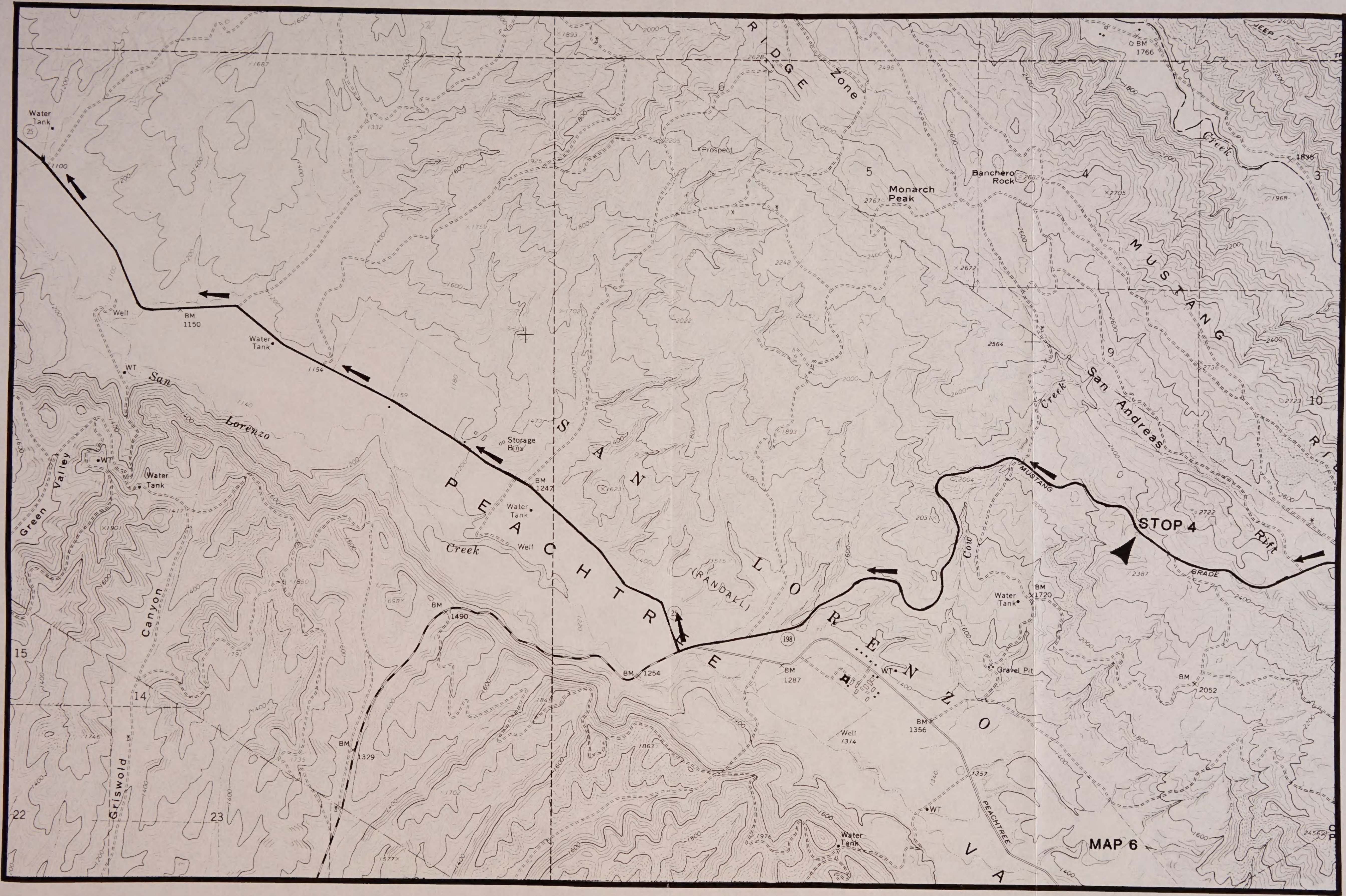


Gravelly Flat
Water Tank
2639
Spring
Water Tank
Hans
Grieve
Canyon
Hog
Canyon
Echo
Canyon
Canyon
Grabast
Canyon
Little
Oak
Flat
Kreyenhagen Peak
Oak Flat
Flag Peak
N I P E R
N T A I N
Markland
Canyon
STOP 3
Coalinga Mineral Springs
Hot
Springs
Canyon
Graves
COALINGA MINERAL SPRINGS ROAD
Warthan
Creek
Bee Canyon
Dogwood Can
BM 1842
BM 1780
Water Tank
Dutchman Can
TRAIL
JEEP
MAP 4



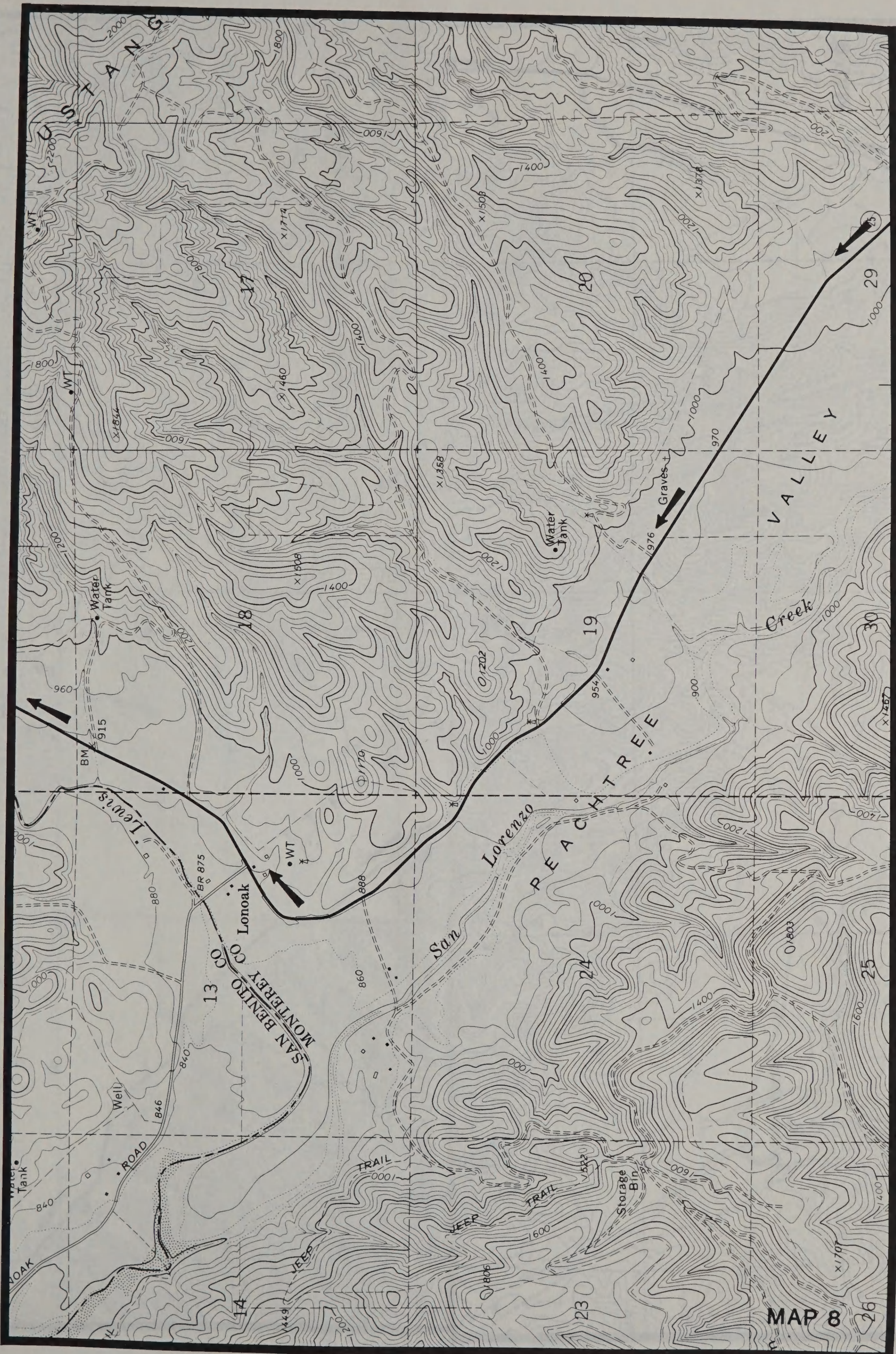
SAN BENITO CO
MONTEREY CO
Lewis Creek
Clayton Cem
MUSTANG GRADE
NORTH FORK
PRIEST VALLEY
Priest Valley Sch.
BM 2198
BM 2256
BM 2488
BM 2946
BM 2874
BM 2292
BM 2361
BM 2518
BM 2179
Water Tank
Indian Spring
Blue
MUSTANG RIDGE
Spring
Log Cabin Spring
PRIEST VALLEY ROAD
Lewis Creek
SAN LORENZO
(RANDALL)
Buckeye Spring
SAN ANDREAS RI
Monroe Valley
Mulch
TRAIL
Canyo

MAP 5

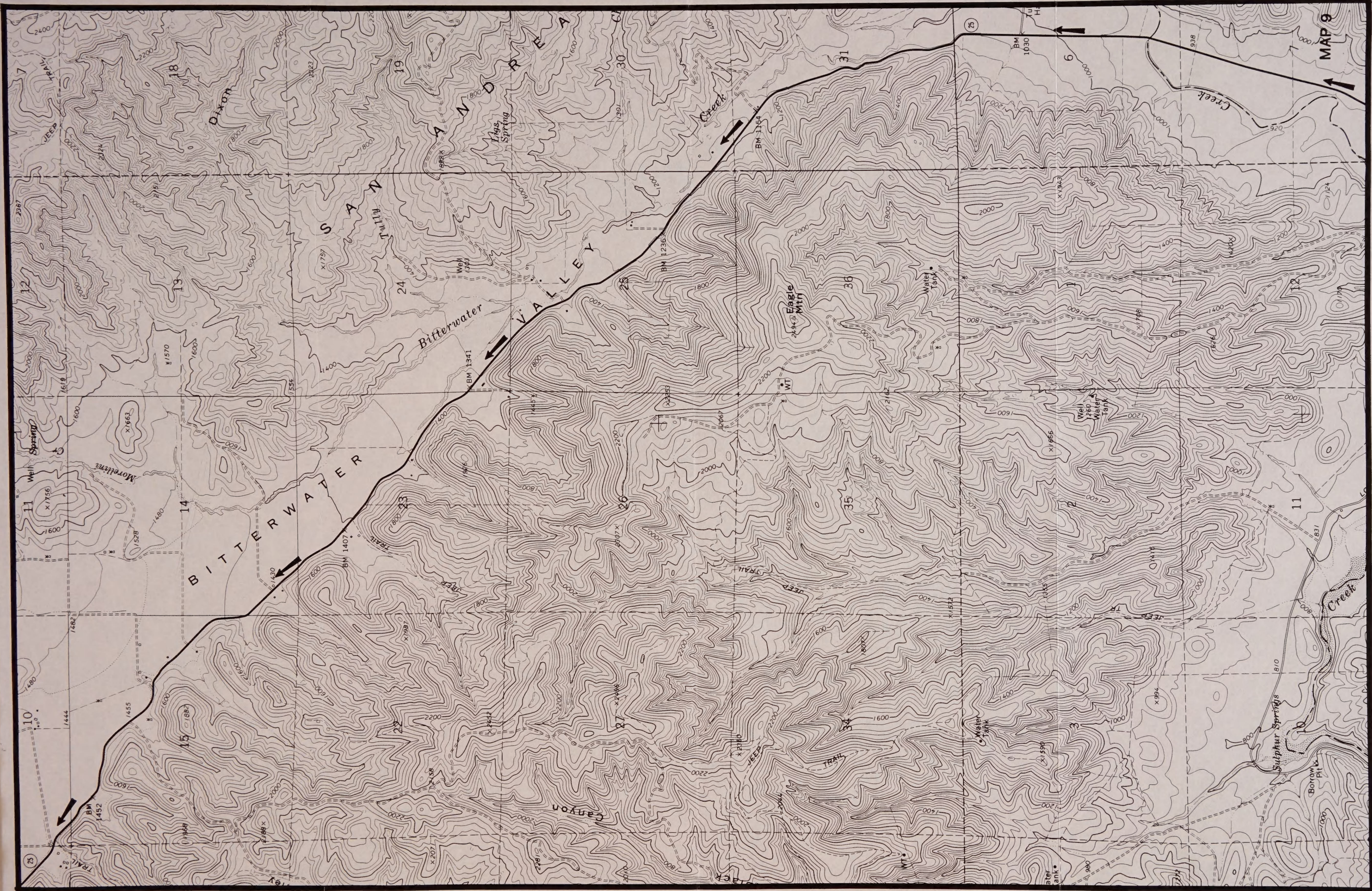


RIDGE Zone
Monarch Peak
Banchero Rock
MUSTANG RIDGE
San Andreas Rift
SAN LORENZO VALLEY
PEACHTREE VALLEY
San Lorenzo Creek
Green Valley
Griswold Canyon
Cow Creek
Mustang Creek
MUSTANG GRADE
(RANDALL)
STOP 4
Storage Bins
Water Tank
Well
Gravel Pit
Prospect
PEACHTREE
MAP 6

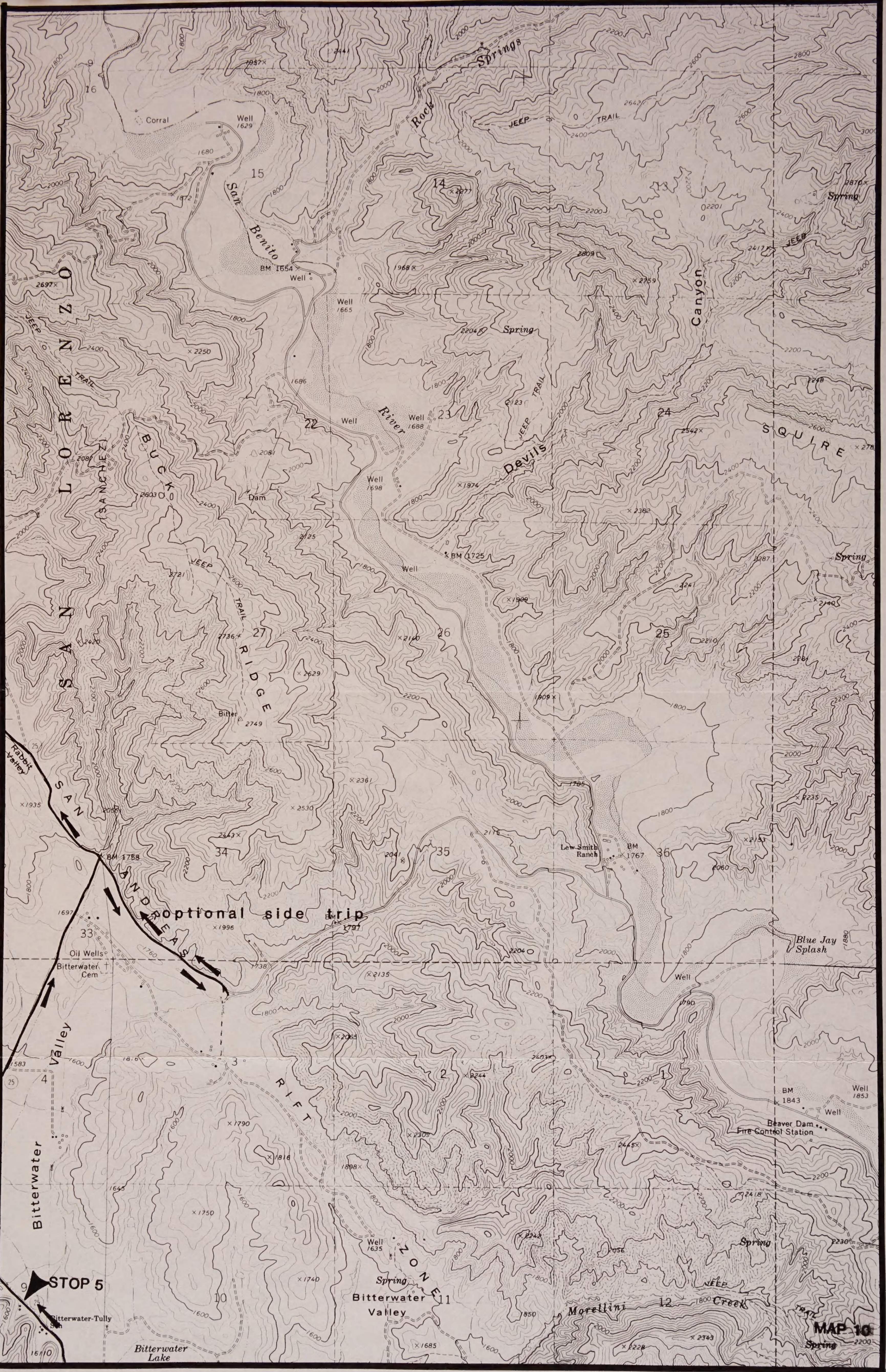

26
25
30
29
28
27
Water Tank
JEEP TRAIL
PEACHTREE
San Lorenzo
Beeman 1467
34
Canyon
35
36
31
32
33
BM 1085
Beeman
VALLEY
Sweetwater 1945
JEEP TRAIL
Creek
Eade No 1 1509
2
1
6
5
SAN LORENZO
Water Tank
(RANDALL)
Water Tank
Water Tank
WT
11
12
7
8
9
Tom
Valley
Water Tank
ALLEY
MAP 7


PEACHTREE VALLEY
San Lorenzo
Creek
Lonoak
SAN BENITO CO
MONTEREY CO
Lewis
Graves
Water Tank
Storage Bin
JEEP TRAIL
ROAD
Well
WT
BM 915
BR 875

MAP 8



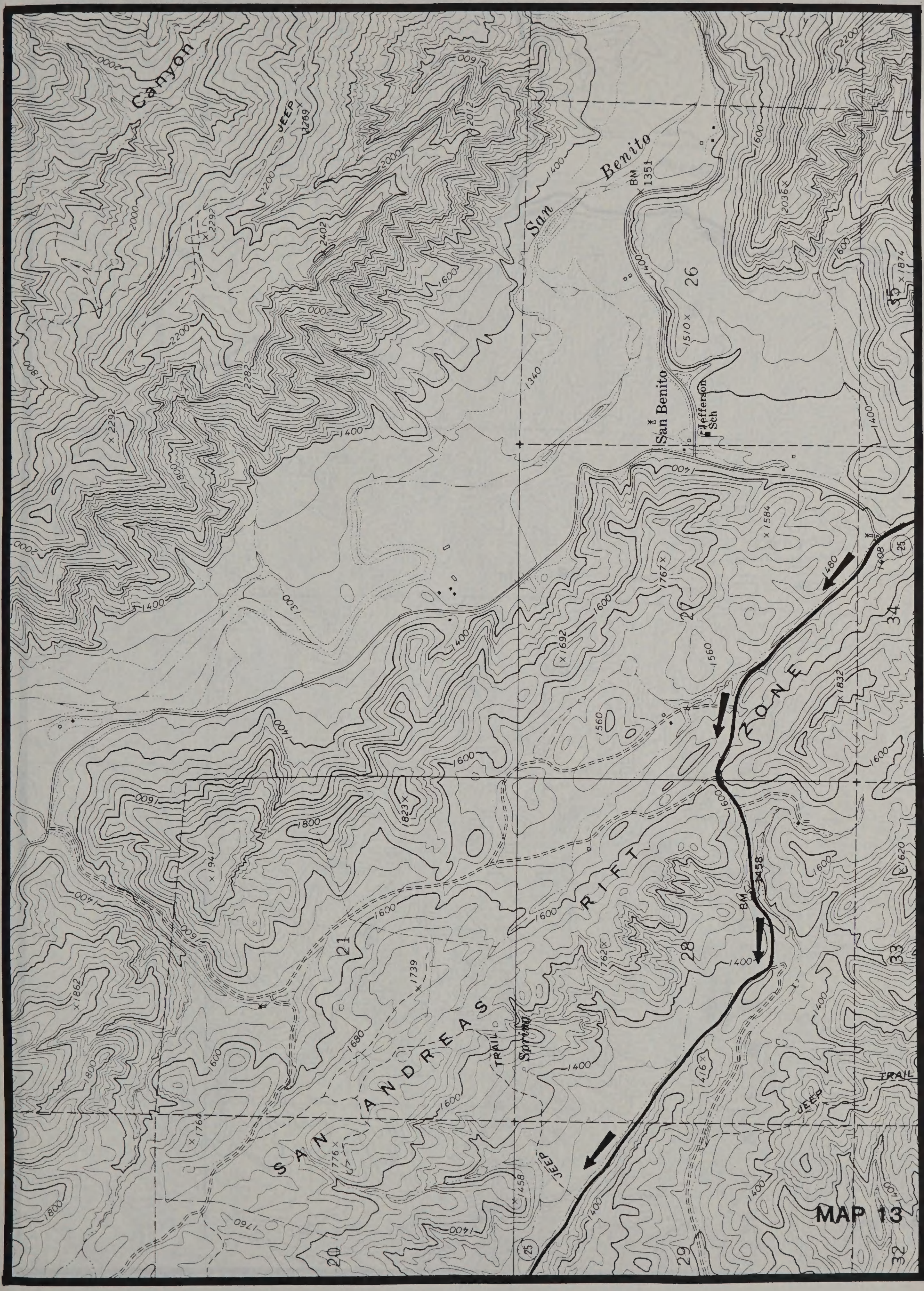
MAP 9
SAN ANDREA
BITTERWATER
VALLEY
Bitterwater
Creek
Eagle Mtn
Canyon
Sulphur Springs
Borrow Pit
Water Tank
JEEP TRAIL
Dixon

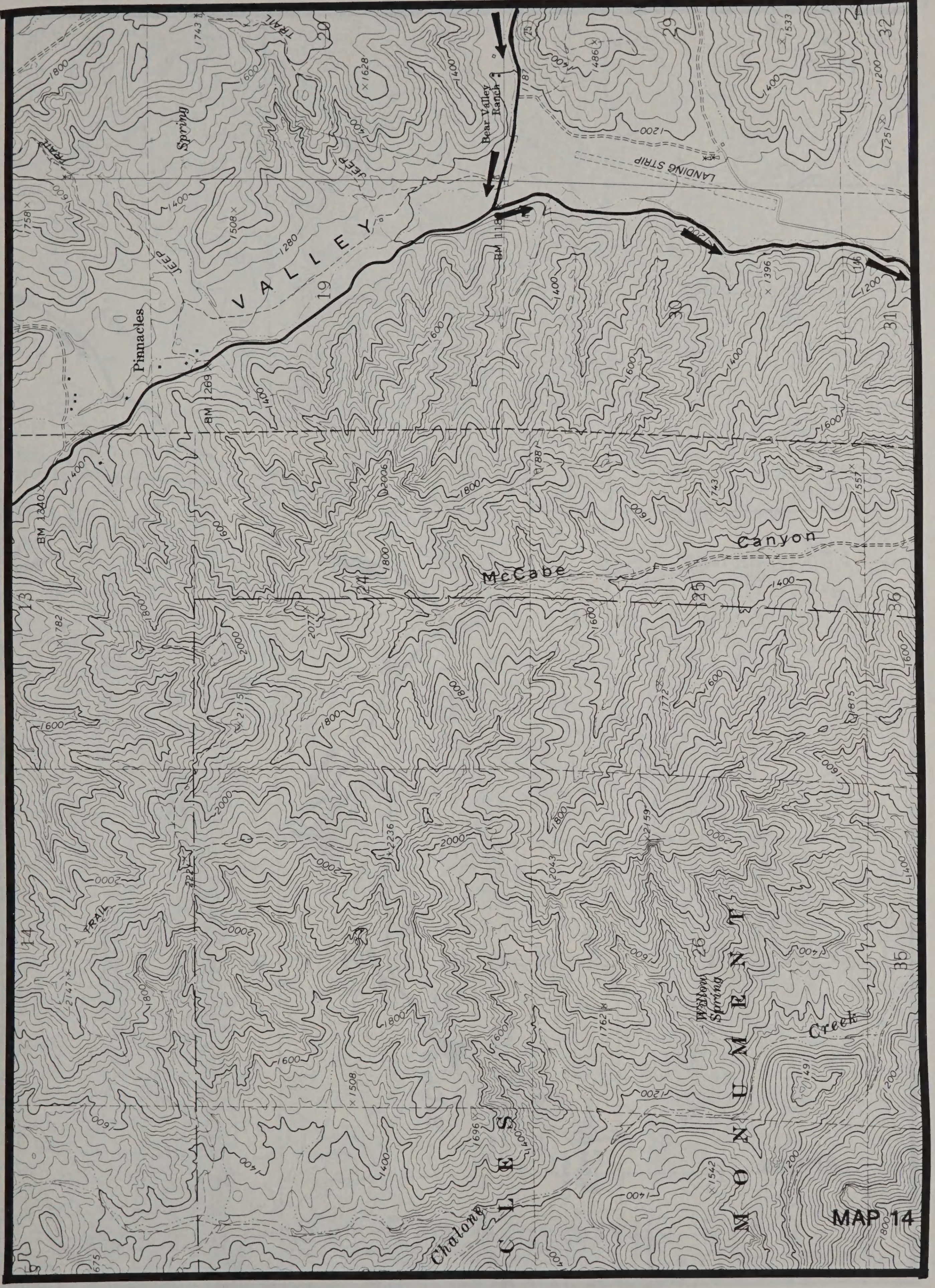


MAP 10
STOP 5
optional side trip
SAN ANDREAS RIFT ZONE
SAN LORENZO
(SANCHEZ)
BUCK RIDGE
SQUIRE Canyon
San Benito River
Devils
Rock Springs
JEEP TRAIL
Corral
Dam
Lew Smith Ranch
Blue Jay Splash
Beaver Dam Fire Control Station
Oil Wells
Bitterwater Cem
Bitterwater Valley
Bitterwater Lake
Bitterwater-Tully
Morellini Creek
Rabbit Valley
Spring
Well


MAP 11
Rabbit Valley
Valley
Bitterwater Valley
Bitterwater
BITTERWATER ROAD
LORENZO
(SANCHEZ)
SAN
VALLEY
JEEP TRAIL
Storage Bin
Water Tank
Well
Sans Ranch
Spring
Quarry
Creek

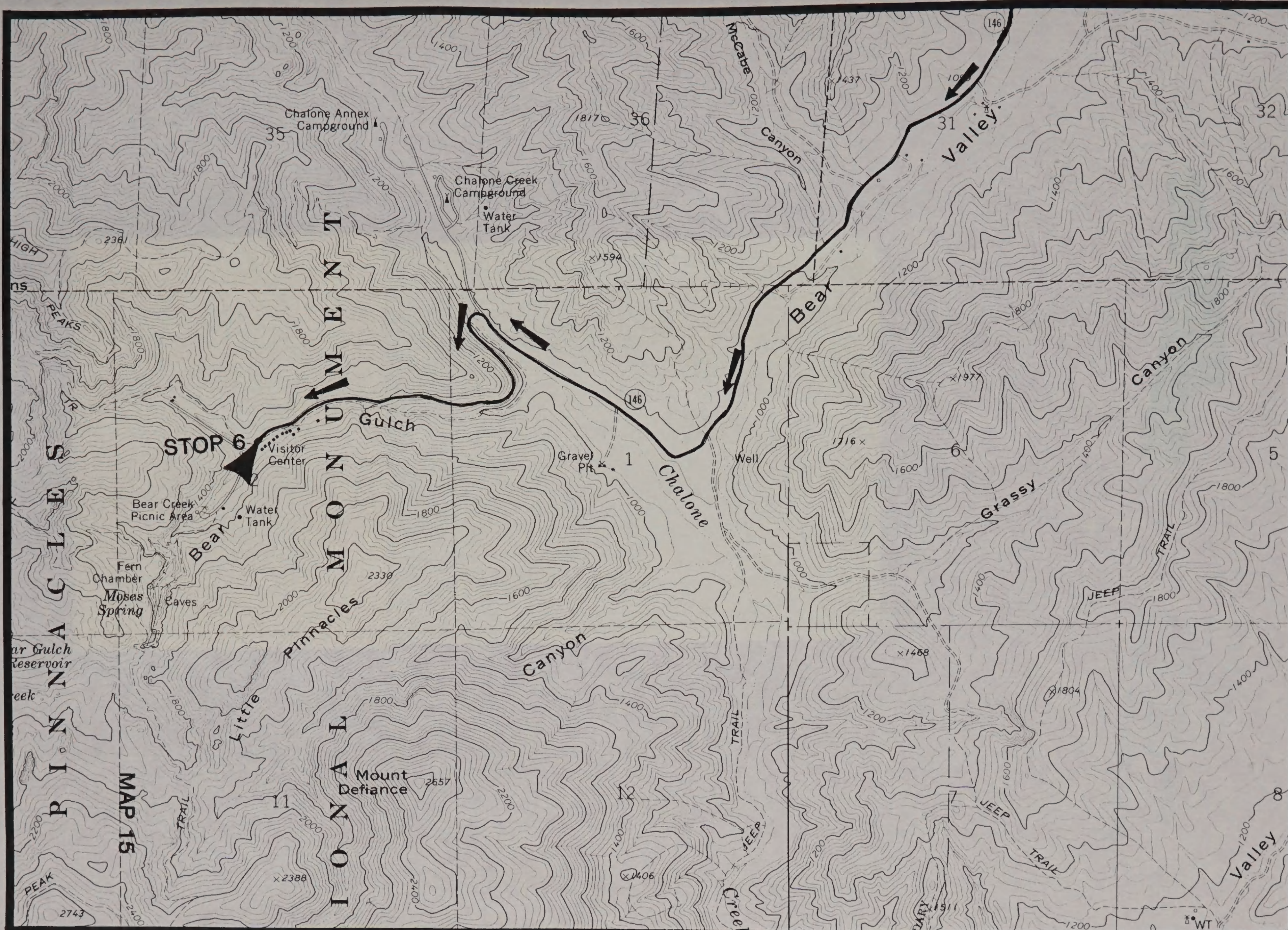

BUCK RIDGE
SAN ANDREAS RIFT
Little Rabbit
Dry Lake Valley
Dry Lake
San Benito River
Smoker Canyon
Footbridge
New Mill Canyon
Canyon
Spring
Water Tank
JEEP TRAIL
BM 1386
BM 1404
BM 1517
Topo 2146
MAP 12


Canyon
JEEP
San Benito
BM 1351
San Benito
Jefferson Sch
SAN ANDREAS RIFT ZONE
TRAIL
Spring
JEEP
JEEP TRAIL
MAP 13



VALLEY
Pinnacles
Spring
JEEP
TRAIL
Bear Valley Ranch
LANDING STRIP
McCabe
Canyon
Willow Spring
Creek
Chalone
CLES
MONUMENT

MAP 14



MAP 15
STOP 6
Visitor Center
Water Tank
Bear Creek Picnic Area
Caves
Fern Chamber
Moses Spring
PINNACLES NATIONAL MONUMENT
Mount Defiance
Little Pinnacles
Bear Gulch
Chalone Creek Campground
Water Tank
Chalone Annex Campground
Bear Valley
McCabe Canyon
Grassy Canyon
Chalone Creek
Gravel Pit
Well
146

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